University of Alberta

INNOVATION, TECHNOLOGY, DESIGN

Refocusing Product Creation on Empowerment

BY

HUIWEN JI

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Design

In

Industrial Design

Department of Art and Design

Spring 2012
Edmonton, Alberta

ABSTRACT

Product design is a valuable asset to businesses because it enables companies to maintain competitiveness against intense rivalries. The creative nature of design is being viewed as an ideal source for infusing innovativeness into product development processes. Yet instead of striving for better products that enrich the quality of human life and experience, many companies are merely using innovation as a business strategy, or more precisely, a marketing tactic, for differentiating their products and services from other competing alternatives. This has resulted in a fundamental misalignment between why designers are being hired, and the true values of their works.

This thesis aims to develop, test and validate a set of design guidelines and principles specifically tailored to restore the clarity and focus of product design through investigations and analysis of the intertwining relationships between innovation, product creation, technology, business and people, and their respective goals, purposes and motivations.

ACKNOWLEDGMENT

I wish to extend my deepest gratitude to my supervisor Tim Antoniuk for his guidance, inspiration, encouragement and above all continuous support through the course of this study. I must also thank my other committee members Aidan Rowe, Arlene Oak, Cezary Gajewski, and Robert Lederer for their invaluable comments and support.

I am indebted to the faculty, staff, and graduate students of the Department of Art and Design for their support over the years. I am especially grateful to Cezary Gajewski and Patrick von Hauff for all of their invaluable inputs that help shaped the course of this work.

I would also like to thank Fan Lin, Yiran Wang, and Emma Zhang for lending their technical expertise in all aspects of this study.

Finally, I would like to thank my parents and my wife for their unconditional support and belief in me.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

In an early interview[1] Steve Jobs called the computer "a bicycle for our minds," he explained:

> *I think one of the things that really separates us from the high primates is that we're tool builders. I read a study that measured the efficiency of locomotion for various species on the planet. The condor used the least energy to move a kilometer, and humans came in with a rather unimpressive showing about a third of the way down the list. It was not too proud a showing for the crown of creation. So that didn't look so good, but then somebody at Scientific American had the insight to test the efficiency of locomotion for a man on a bicycle, and a man on a bicycle, or human on a bicycle, blew the condor away, completely off the top of the charts, and that's what a computer is to me. What a computer is to me is, it's the most remarkable tool that we've ever come up with. It's the equivalent of a bicycle for our minds.*

This was not an exclusive analogy, in fact, all tools were built as extensions of human senses and capabilities and are means of amplifying human functions,[2] but what is more important, is that we inherently seek ways to exploit those capabilities to fulfill our own purposes, and this need to better fulfill our human purposes in turn, drives further enhancements of the tools already in use. It also determines which capabilities would get enhanced rapidly and which other ones would be destined for deterioration when no longer needed.

Now if we take the same perspective and think of design as also a tool for enhancing capabilities, perhaps it would make some of us pause, and start to wonder, which capabilities, then, does design enhance exactly, and what purposes are currently driving the development of design from behind?

---

[1] Memory & Imagination: New Pathways to the Library of Congress. Dir. Michael R. Lawrence. Michael Lawrence Films. DVD.

[2] Lawson, Clive. "Technology and the Extension of Human Capabilities." Journal for the Theory of Social Behaviour 40.2 (2010): 207-23. Print.

Obviously, different tools are designed for different uses, their intended functions are predefined by their original inventors. The inventors of design are designers, and designers design for many different reasons. Some design to inspire others[3], some want to save the planet, some see imperfections and strive to make the world a better place, some are opportunists ... each works for a different cause, and as such, each should be rightfully evaluated by his or her own merits. On the other hand, what purposes a capability, supported by the tool, fulfills are usually governed by what the tool is *actually* being used for in the real world, which may sometimes differ from what the tool was originally designed for. Despite individual differences, designers working in similar domains are often being deployed to fulfill similar purposes. Unlike personal pursuits and motivations, these shared purposes affording the usage of design are not self-imposed, instead they are defined by those who chose to adopt design: the collective of non-designers who see design as a functional tool carrying the capabilities of helping them achieve their own goals. It is these shared purposes that dictate the reasons why designers survive.

As Greg Anderson wrote[4]:

> *You were born to greatness. Having a life mission implies that the world has need of you. In fact, the world has been preparing you to fill this need with one incredible life experience after another. Finding and fulfilling your potential will lead you to your highest experience in this life. Believe it, you have a mission. It is the gateway to your personal greatness.*

Designers matter because there are people that need them, the better they can satisfy those needs, the more valuable they become. The primary use of product design, including industrial design, user interface design, interaction design, user experience design, and usability engineering, is for extending companies' capabilities to innovate, because innovation holds the key to solving one of the biggest challenges facing businesses of all sizes today, that is how to distinctively

---

[3] This includes designers like Anthony Dunne and Fiona Raby

[4] Anderson, Greg. Living Life on Purpose: a Guide to Creating a Life of Success and Significance. [San Francisco]: HarperSanFrancisco, 1997. Print.

differentiate their products and services from that of their competitors and avoid commoditization. Innovation helps products and companies standout, innovation makes them unique and valuable. When your product promises great values to your potential customers and you are the only company making it, you won't need to compete on price, and two things will happen next: A. you will sell more units, and B. your profits will soar through the roof. When giving a talk at a User Experience design conference, Brandon Schauer declared:

> *There is no reason for a company to support a great experience unless it makes money. If there is no economic incentive, it either can't exist (unsustainable) or it's art.*[5]

The same holds true for product design in general. It's important to note here though, that I will not try to debate in this thesis on the morality of whether design should be purely used for business purposes, instead, I'm only acknowledging this cause and effect relationship existing between design as a tool, innovation as a capability and financial growth as a purpose. This thesis is a preliminary study on product design's relationship with innovation and is aimed at obtaining a basic understanding of where and how design can be better positioned in the innovation process and the research presented in this thesis was carried out to address the following (research) question.

If the predominant purpose of product design is to amplify innovative abilities of product companies, how well is design currently attending to this need, and what can we do to further enhance its performance in fulfilling its duties?

In a design research conference talk[6], Donald Norman pointed out that there is a fundamental gulf between the design research community and the products

---

[5] Schauer, Brandon. "The Business Case for (or Against) UX." Speech. User Interface 16 Conference. Boston. LukeW Ideation + Design. Luke Wroblewski, 9 Nov. 2011. Web. 10 Nov. 2011. <http://www.lukew.com/ff/entry.asp?1445>.

[6] Norman, Donald A. "The Research-Practice Gulf." IIT Design Research Conference 2010. Spertus Institute, Chicago. May 2010. Speech.

Norman explains, design and design research is often being evaluated by the quantities of ideas, the cleverness of solutions, winning design competitions and journal and conference publications, and they are not measured by whether a resulting product was successful in the market.

community, and this has resulted in a mismatch between what designers do and what the industry needs. What I would argue in this thesis is that this design-product gulf was caused, instead, by a fundamental misalignment between designer's highly diversified self-imposed motivations (or why designers design), and the industry's actual need for design (or why designers are hired to design). As such, the design processes and methods we use today are not optimized for churning out successful products and innovations.

To grasp the complexity of this problem, and seek solutions, I then worked backwards from the corporate end and identified "innovation" and "success" as two key underlying concepts that needed to be fully understood. So by asking first, *what is innovation, and where does design fit in,* and second, *how do we measure success in innovation, and how do we design for it,* I was able to develop a new set of design principles that's more suited for product innovation.

The first half of this thesis is mainly consisted of secondary research and analysis done on a broad range of topics related to innovation, technology and design, and is augmented by case studies. The second half of this thesis consists a combination of literature reviews on technology adoption and innovation diffusion theories, and an in-depth case study of an iPhone application design project I have recently completed using the design methods and principles I have developed in this thesis.

Key theoretical models and frameworks that influenced the direction this thesis include Rajesh Chandy and Gerard Tellis' model of innovation[7], W. Brian Arthur's theory of the origins and evolution of technology[8], Steven Johnson's seven patterns of innovation[9], Indi Young's mental models[10], Eric von Hippel's model of

---

[7] Chandy, Rajesh K., and Gerard J. Tellis. "Organizing for Radical Product Innovation: The Overlooked Role of Willingness to Cannibalize." Journal of Marketing Research 35.4 (1998): 474-87. JSTOR. Web. 13 Nov. 2011. <http://www.jstor.org/stable/3152166>.

[8] Arthur, W. Brian. The Nature of Technology: What It Is and How It Evolves. New York: Free, 2009. Print.

[9] Johnson, Steven. Where Good Ideas Come From: the Natural History of Innovation. New York: Riverhead, 2010. Print.

[10] Young, Indi. Mental Models: Aligning Design Strategy with Human Behavior. Brooklyn, NY: Rosenfeld Media, 2008. Print.

lead-user innovation[11], and a collection of theoretical models of innovation diffusion and technology adoption.

[11] von Hippel, Eric. Democratizing Innovation. Cambridge, MA: MIT, 2005. Print.

2. BACKGROUND

There will always be inventors, and there will always be adopters. Inventors invent, and the ones who see values in inventions will make decisions to adopt (or reject). Yet the two worlds are not always perfectly aligned. When an invention takes place, there is usually a targeted audience group on the one end, defined by the original inventor or maybe by a marketing agency based on the specifications of the original invention, and there is always an actual potential adopter group on the other end, of those who find the invention attractive. Often there will be overlaps between the two groups, but it is when they don't intersect that things will start to get interesting. (Figure 2-1)

Figure 2-1 Target audience versus potential adopters

People don't always adopt new things for its intended purposes, sometimes they discover undocumented alternative ways of using a tool better suited with their needs. Even when they knew full-well it was not how the original inventor designed it to be used, they used it anyway. Are these people targeted audience? Certainly not. Are they adopters? Definitely. Will the original invention be

modified to accommodate these unintended uses? Perhaps, if there is enough people out there agrees with the new uses, then yes, I would propose that eventually changes will be made.

Error, serendipity and exaptation are three of the most common sources of innovation.[12] Among the various things we take for granted today, a considerable portion of them were not originally designed to handle the tasks they now perform. AM Radio was first patented as "wireless telegraphy" back in 1896, but it was not until 1920, that the first commercial AM radio station began broadcasting, and it took almost ten years after that for radios to become common household appliances in America. If fact, this is usually how radical innovations are born, they evolve and then they reinvent themselves from their earlier forms of inventions. The first computer was designed to be a fast calculator,[13] the first GPS was born serendipitously from two American physicists' attempt to calculate the position and the orbit of the Russian satellite Sputnik using the Doppler effect,[14] and the Internet didn't take off until Tim Berners-Lee threw the World Wide Web into the mix.[15]

However, serendipitous innovations do not come easily, it takes a great deal of time, a great deal of imagination and possibly many failed attempts of divergent exploration for the right connections to establish, between the amplified capabilities achieved from technological advancements and the best place for it to fully deliver its potential. This is very different from conscious, calculated innovations where predefined goals drives the developments of inventions and their subsequent refinements.

Every time a new breakthrough is achieved, numerous new possibilities will begin to emerge, along with these possibilities, uncertainties abound. As the new

---

[12] Johnson. Where Good Ideas Come From: the Natural History of Innovation.

[13] Kopplin, John. "Computer History." Computer Science Lab Home Page: Learn Computer Programming. Computer Science Lab. Web. <http://www.computersciencelab.com/ComputerHistory/History.htm>.

[14] Johnson. Where Good Ideas Come From: the Natural History of Innovation.

[15] Bidgoli, Hossein. The Internet Encyclopedia. Hoboken, NJ: Wiley, 2003. Print.

invention is put into use, different possibilities are tested and evaluated, knowledge about the new invention is gathered, new information are discovered and uncertainties are reduced. Once the level of uncertainty gets low enough, decisions will be made regarding the adoption or rejection of certain alternative uses. Further adaptation would be made, and eventually new patterns will emerge. This carries profound implications for designers designing products and interactions, yet it is not common for designers to look at themselves as also a serendipitous invention, constantly being tried, evaluated and adapted.

For over a hundred years, since originally adapted from artists and artisans, designers have been tirelessly reinventing design, exploring alternative directions for its future development. Its focus shifted from traditional craftsmanship to alternative stylings, to wider distribution of quality works and then to fully embracing mass-production, to functionalities, to ergonomics, and to usability and experiences. Some traits design had developed were accepted and adopted by others, while some were rejected and abandoned[16]. Because eventually, the fate of inventions will be determined by whether they can attract enough adopters and get mass-market [17] acceptance, failing to reach the tipping-point, the inventions will eventually end up in defeat. After over a century of divergent exploration, a sub-branch of design has finally crossed the chasm[18], and is starting to quickly diffuse across diverse industries. This sub-branch is commercial product design.

---

[16] For example, Arts and Crafts Movement eventually failed because of its opposition to mass-production.

[17] By market I don't necessarily mean a commercial market, but rather having a large enough audience that have developed demand for the invented tool.

[18] Moore, Geoffrey A. Crossing the Chasm: Marketing and Selling Disruptive Products to Mainstream Customers. New York: CollinsBusiness Essentials, 2006. Print.

Based on the diffusion of innovations theory from Everett Rogers, Moore argues there is a chasm between the early adopters of a new invention (the technology enthusiasts and visionaries) and the early majority (the pragmatists) as visionaries and pragmatists have very different expectations and it is most difficult for the makers and marketers to reach the tipping point between the two groups. However, as Moore points out, once a firm succeeds in creating a bandwagon effect in which enough momentum is built to cross this chasm, then the product would easily become a de facto standard.

2.1.Where Product Design Fits

David Liddle, the project leader of the Xerox Star's design and development team, has a simple three-phase technology development model[19], which he outlined as the enthusiast phase, the professional phase and the consumer phase. In each one of these stages, as Liddle explains, the required skills and processes differ dramatically, because the audience in each phase have very different demands and expectations towards the new technology. Although Liddle's definition of technology is rather narrow, considering his background is personal computing, his observations and assumptions can be quite inspiring if we apply the same outlook to design itself.

Design, as methods or processes, is a technology by definition[20]. As technologies develop, evolve and spread, they undergo transitions, similar to what Liddle had described, and the criteria for judging their performances and determining their successes and failures will change accordingly. Presently, commercial product design is undergoing such a transition, and consequently, what accounts for good design is also slowly adapting.

If you know the law of diffusion of innovation, or the technology adoption lifecycle, you would know that by definition[21], when it comes to adopting a new technology, about 2.5% of our population are innovators, 13.5% are early adopters, and there are early and late majorities both taking about 34%, and then at last, there are laggards which makes about 16%.

Innovators are often the first ones to recognize potential benefits in adopting new inventions. They are usually extremely motivated by those benefits that they tend to share a higher than normal tolerance for any deficiencies and/or possible

---

[19] Moggridge, Bill. "Adopting Technology." Designing Interactions. Cambridge, MA: MIT, 2007. Print.

[20] Arthur. "Combination and Structure." The Nature of Technology.

In this chapter Arthur gave three definitions to technology. The first is that technology is a means to fulfill a human purpose, some are explicit and some may be hazy, multiple, and changing, and as means, technology can be a method or process or device. The second is that technology is an assemblage of practices and components. The third definition is that technology is the entire collection of devices and engineering practices available to a culture.

[21] Rogers. Diffusion of Innovations.

chances of failures. At this stage, there is little need for the original inventors to modify their inventions to satisfy the needs of potential adopters. Innovators are best at identifying uses for novel inventions on their own.

Early adopters are also among the first ones to try out new inventions. Different from innovators, early adopters are mostly opinion leaders of their local social systems responsible for handing out seals of approval to new inventions. In order to appeal to early adopters and earn their recommendations, inventions need to be carefully executed and refined to exhibit clear advantages over existing alternative technologies or at least the potential to gain superior status in the foreseeable future, this often requires original inventions be adapted to suit the demands of potential adopters. Early adopters usually hold strong opinions toward new inventions in terms of their potentials to leapfrog existing technologies, their values and costs. Their opinions can often heavily influence further developments of new inventions.

Early and late majorities are different. These later adopters are heavily influenced by opinion leaders and their peers around. They definitely will not try a new product before someone else has tried it first, but what is more important, is that an early majority, in some cases, would adopt a new product simply because an opinion leader has adopted it. Once an invention has started to diffuse among later adopters, the major motivation for adoption would begin to shift from evaluations of potential benefits and possible costs to social influence and peer pressure, and the *cause* of the invention would start to go fuzzy. When that happens, it will become harder and harder to improve an existing technology by studying what potential adopters would want and/or analyzing feedbacks from existing users.

The diffusion of design for commercial uses is in transition from attracting earlier adopters to enticing later adopters. When design first captured the attentions of businesses, its primary function was deemed as styling,[22] and its core value lies in its ability to increase products visual attractiveness, which

[22] Bürdek, Bernhard E. Design: History, Theory and Practice of Product Design. Basel: Birkhäuser, 2005. Print.

resulted in better sales and higher profits. At first, a handful of companies saw this value in design, and they adopted it and exploited it. Now fast forward to today, design has evolved and developed many more qualities beneficial for businesses, but the path had not been smooth. Although it seems obvious to businesses, that contributing to a company's differentiating value proposition through creativity and innovation is the only reason designers are being hired, the design community on the other hand usually appears to have intentions of its own. While design was gradually exploring its boundaries and expanding its capacities, businesses was slowly embracing some of the new capabilities design had developed as well as rejecting others that were not relevant to solving their needs. As commercial product design enters the mass market, more and more companies are starting to adopt the use of designers, and as designers' capabilities and expertise branch off into distinct directions, product design is becoming increasingly fragmented, and it is becoming growingly hard for us to further improve design as a coherent tool for enhancing companies' capacities for innovation.

In product design, each sub-design category carries its own set of valuable qualities, and each can be utilized as a standalone component by businesses for adding to their overall product competitiveness. Companies are multidisciplinary systems where each component serves only a small fraction of the entire system's needs. As new components are developed, they can be absorbed by the system to replace older, less efficient parts, or act as new components to increase the overall performance of the system.

When design went through the innovator and early adopter stages of diffusion, its capabilities grew exponentially as designers (inventors) and companies (adopters) discovered new ways to embrace the values of design. However, because the various uses of design developed over decades, and was individually explored and separately adopted by different companies across industries, over time, design slowly grew fragmented. Styling successfully brought many hideous products of the postindustrial revolution era closer to people by making them aesthetically more attractive to average consumers. Careful functionality considerations intensified the performances of many products over their

predecessors and made them more valuable. Material and manufacturing process explorations resulted in cheaper to make yet better quality products. Usability helped decreasing users' cognitive loads and transaction costs. User experience design made interactions less stressful and more delightful. All aimed at making better products, but there is no sign of convergence.

As integrated systems, product companies are not operated by designers alone, they require collaborations from many disciplines to work together toward the same goals. The process of churning out new products is a continuum along which we all sit at various points. There are company executives, directors and managers of all sorts overseeing the operations of the company, there are marketing and sales personnel responsible for discovering market opportunities, business development and communicating and interacting with customers, and there are research and development centers filled with researchers, technologists, developers and engineers working to turn visions into reality and to explore new possibilities for future product developments, however, when it comes to designers, it can be quite challenging to pin down exactly where they would fit. Designers are everywhere.

2.2.The Missing Piece

Another important reason behind the fragmentation of design is that the idea of using designers to make better products came as an exaptation, meaning designers were originally adapted from other fields and used for new purposes, but unlike when Johannes Gutenberg took the wine press and turned it into the printing press[23] which was an all-inclusive machine for an exclusive purpose, designers were adapted from artists and artisans as additional components to an existing system and were used to fulfill only a very narrow subset of purposes. This sets design apart from other disciplines like management or marketing or engineering where all of those were conceived and constructed from the ground-up to serve their original purposes, and not as supplements.

---

[23] Johnson. Where Good Ideas Come From: the Natural History of Innovation.

Further exaptations continued as product design evolved over the years, useful ideas were taken from engineering, from computer science, from marketing and from psychology, but there has never been any effort to acknowledge a common purpose or goal that can be shared among different designers and use it to help steer the development of design as a unified discipline. Simply put, product design has not found its best use scenario like AM radios or computers did.

Now, going back to the adopters' end, we know product companies need to keep innovating to stay competitive, but what is innovation exactly, and what does that have anything to do with design? Why would they need designers? According to Kuniyoshi Urabe[24]:

> *Innovation consists of the generation of a new idea and its implementation into a new product, process or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise. Innovation is never a one-time phenomenon, but a long and cumulative process of a great number of organizational decision-making process, ranging from the phase of generation of a new idea to its implementation phase. New idea refers to the perception of a new customer need or a new way to produce. It is generated in the cumulative process of information-gathering, coupled with an ever-challenging entrepreneurial vision. Through the implementation process the new idea is developed and commercialized into a new marketable product or a new process with attendant cost reduction and increased productivity.*

There are three key concepts in this definition, and together they set innovation apart from inventions or pure visions. The first, is new ideas. Everything starts with an idea, what makes innovation different is the new ideas that drive innovations need to either be able to resonate with large numbers of potential customers, or have the ability to cut costs or increase productivity in making existing products or delivering existing services. The second, is implementation and/or commercialization, meaning the ideas in innovation cannot be just any

---

[24] Urabe, Kuniyoshi, John Child, and Tadao Kagono. "Innovation and the Japanese Management System." Innovation and Management: International Comparisons. Berlin: W. De Gruyter, 1988. 3. Print.

good ideas, but have to be the ones practical enough to be implemented and commercialized. Therefore, one can argue that implementation is equally as important as having good ideas if not more to innovation, and it makes a lot of sense, because without implementation, no matter how good your ideas are, they will always stay as ideas. The third, is economic growth. An innovation has to generate economic values, it needs to attract customers, build up demands, meaning ideas behind the innovations need to be accepted by the customers and get adopted.

To get all three of these things right, a company will need the expertise to connect with its potential customers and understand what their needs, wants and expectations are, and the company will also need to understand what its own processes are and how its organizations functions, in addition to that, the company will most certainly need people with the technical know-hows to realize their visions and turn them into tangible products and services, but besides all that, there is something else missing. For a company to successfully deliver its innovations to its customers, it needs to have someone with the ability to understand the best of both the consumers world as well as the technical world to be able to accurately translate customers' goals into executable technical specifications and ensure the implementation of the company's visions and ideas aligns well with their customers' expectations. After all, what matters the most in the end is not about the money you make by selling your innovation, it's not about the technologies that made it possible, it's not even about the idea to do it in the first place, instead it should be about the potential adopters of your innovation, about people looking at your innovation and seeing reflections of their own lives and works in it, and seeing themselves benefiting from adopting and using your innovation.

Would a company get to do this last important step right by hiring designers? It sounds awfully like the picture designers are trying to paint themselves in, I would say maybe, but only partially. Over the years, designers have developed a keen ability to empathize with people, while at the same time, many designers are also general technical experts in their own area of expertise. For example, industrial designers usually have a great deal of knowledge about various

manufacturing processes and techniques as well as different material properties, many web and user interface designers excel at programming skills, and most furniture designers have the technical knowledge and abilities to build furniture on their own. However designers too seem to be struggling quite a bit in trying to fill this much needed role in the innovation process as a central hub connecting people, products, technologies and the market.

At first, I suspected this may be partly due to the increases in the degree of fragmentation and isolation that is taking place in design, with graphic designers doing graphic design, industrial designers looking after only hardware, and interaction designers taking charge of software design...each doing their own little thing without collaboration, but as I dug deeper, I realized, there is something much more fundamental, that's blocking design from fully realizing its potentials.

2.3.Design + Technology, Co-innovate.

While surveying existing literature on design's relationship with innovation, I found there are three rather opposing views being held in the design community. The most common view is that design's biggest role is to create new things, which is to innovate, therefore involving design in any innovation process should be beneficial. The second view is rather controversial, and is being led by Don Norman [25], which essentially says there is little empirical evidence that would support the first view, and that (user-centered) design is only useful in creating

---

[25] Norman, Donald A. "Technology First, Needs Last: the Research-product Gulf." Interactions 17 (2010): 38-42. Print.

In this journal article Don Norman proclaims that" design research is great when it comes to improving existing product categories but essentially useless when it comes to new, innovative breakthroughs."

Norman writes "Although we would prefer to believe that conceptual breakthroughs occur because of a detailed consideration of human needs, especially fundamental but unspoken hidden needs so beloved by the design research community, the fact is that it simply doesn't happen." Instead, as he explains, it is the development of new technology that leads the process of product innovation, following by inventions, and customer's needs in the end. The examples he cited includes the airplane, the automobile, the telephone, the radio, the television, the computer, the personal computer, the internet, SMS text messaging and the cellphone.

step-by-step improvements that result in incremental innovations but essentially useless in introducing leapfrog products and conceptual breakthroughs. The third view, proposed by Roberto Verganti[26], believes that there are two ways that lead to radical innovations, one is through a technology breakthrough, and the other is through a carefully designed meaning change which ought to be led by designers.

TYPES OF PRODUCT INNOVATION

		CustomerNeed FulfillmentPer Dollar	
		Low	High
Newness of Technology	Low	Incremental Innovation	Market Breakthrough
	High	Technological Breakthrough	Radical Innovation

Chart based on Chandy 1998

Figure 2-2 Types of product innovation

These prompted me to further investigate the differences between incremental and radical innovations, and why designers are having trouble dealing with the latter. Among the many different ways to categorize innovation, I found Rajesh Chandy and Gerard Tellis'[27] model (Figure 2-2) suits the purpose of this thesis best. As Chandy and Tellis explain:

> *Our review of the literature suggests that two common dimensions underlie most definitions: (1) technology and (2) markets.The first factor determines the extent to which the technology involved in a new product is different from prior technologies. The second factor determines the extent to which the new product fulfills key customer needs better than existing products (on a per-dollar basis). Considering two levels (low and high) for each factor leads to four*

[26] Verganti, Roberto. Design-driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean. Boston, MA: Harvard Business, 2009. Print.

[27] Chandy, Rajesh K., and Gerard J. Tellis. "Organizing for Radical Product Innovation: The Overlooked Role of Willingness to Cannibalize." Journal of Marketing Research 35.4 (1998): 474-87.

types of product innovations: incremental innovations, market breakthroughs, technological breakthroughs, and radical innovations.

This four-type categorization model makes it ideal for explaining the three conflicting views of design's usefulness, and it also carries several important implications for defining design's role in innovation.

1. Technology is essential in all four types of innovation. In incremental innovations and market breakthroughs, the newness of technology is low, but it requires proper understanding of the existing technologies for someone to improve upon the current product. In technological breakthroughs and radical innovations, new technologies are developed, and understandings of the new technology and perhaps even the existing technology that's being replaced by the new one is absolutely crucial.

2. Technological breakthroughs can be singular events, but radical innovations are cumulative processes. Radical innovation starts with one or several technological breakthroughs and continue to develop and undergo various incremental improvements and adaptations before it could eventually achieve a market breakthrough. In this process, identifying a vision to fit the capabilities brought by the new technology into people's lives is usually more important for businesses, because in the end, it is usually the company that successfully commercialized a new technology that gets all the incentives not the one invented it.

3. Identifying new ways of using existing core technologies to provide substantially higher customer benefits can also lead to market breakthroughs. Apart from understanding the capabilities and limitations of existing technologies, a keen awareness of potential customers needs is also essential.

What these tell us is that there is simply no such thing as design versus technology in innovation. Technology is the fundamental building blocks of innovation. On top of that, I would go one step further by saying not only programmers and engineers are technologists, designers too are technologists.

As defined by Arthur technology includes methods, processes and devices,[28] therefore, engineers are technologist by nature, as they mainly conceive and develop devices, yet industrial designers too conceive and develop hardwares, and although interaction designers usually work on designs of non-material softwares or services, their works too involve methods or processes. Also, what engineers and designers have in common is that their works are all aimed at either increasing the performance of their goods or services or reducing the associated costs, be it the actual costs of materials or components or the interaction or transaction costs incurring in the process of using a particular product.

However, when it comes to dealing with different types of innovations, engineers and designers would show vastly different characteristics. This is caused by a fundamental difference between how radical innovations and how incremental innovations are developed. In most cases, product companies are structured by what they do. Clothing companies don't sell computers the same way as entertainment companies don't make chocolates. They establish their own technical expertise around the products they make, and their capabilities are therefore directly limited by these specific technology domains. Clayton Christensen suggests[29] there are two types of companies, incumbents and entrants. In many cases, disruptive technological breakthroughs usually originate from outside industries and markets, because what a technological breakthrough is at its core, is using an entirely different set of technologies to achieve relatively similar goals or complete similar tasks an existing product or a group of products used to handle. Yet, since incumbent companies are usually limited by the technologies and expertise directly related to their existing products or services, these companies are usually either unaware of or not sufficient at discovering or developing disruptive breakthrough technologies on

[28] Arthur. "Combination and Structure." The Nature of Technology.

[29] Christensen, Clayton M. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Boston, MA: Harvard Business School, 1997. Print.

their own. Similarly, as outlined by Henderson and Clark,[30] there are certain instances in innovation that knowledge of products components as well as how each component is linked together are enhanced, and other times, these existing knowledge are destroyed because radically different technologies are used.

What Roberto Verganti is arguing is that in dealing with technological insufficiencies design has the ability to push technologies into new product domains and radically different markets. In other words, design can augment innovation through exaptation. The clear benefit of this method is that the process of design usually starts with people, thus it is much easier for us to kickstart an innovation process with a vision as opposed to the use of certain available technologies. Then this vision would drive the search for suitable new technologies. In the end, you can take a set of existing technologies, usually found from outside of your company's usual, familiar domains, and adapt them to deliver the same values or even better, expand the services your existing products provides with much higher performance or much lower cost, therefore achieving a market breakthrough. In some cases, if breakthrough technologies are used, the resulting products or services can even become radical innovations. This design driven approach is extremely valuable because it effectively addresses the aforementioned shortcomings of traditional engineering driven innovation, that is the lack of adaptation and exaptation, and it proves that technology alone, sometimes is not enough to bring about successful innovations and the combination of design plus technology maybe the most valid solution. Two good examples would be the first iPod and Microsoft's Kinect.

When Apple first designed its iMac in 1998, its CEO Steve Jobs wanted it to have a slot CD drive instead of a tray drive.[31] John Rubinstein, who was then the head of Apple's hardware devision, warned him this decision would limit Apple's options in adopting a newer technology that would come out in a year - a CD drive that could rip and burn music, because the new drive would only be made in the old-

---

[30] Henderson, R. M., and K. B. Clark. "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms." Administrative Science Quarterly 35.1 (1990): 9-30. Print.

[31] Isaacson, Walter. "CEO: Still Crazy after All These Years." Steve Jobs. New York: Simon & Schuster, 2011. Print.

fashioned tray form first, but Jobs insisted. This later cost Apple to fall behind in competition agains other PC makers when consumers all started ripping and burning their own favorite musics on their PCs. By that time, people at Apple knew they had to catchup in the music market, and to do that, they had to leapfrog their competitors.

After finally adding a CD burner to the iMac, and developing its own music management software, iTunes, Jobs started pushing for a portable music player in late 2000. That was around when the first portable MP3 players were starting to show up on the market, like the Rio, and Apple spotted this opportunity. But they didn't start right away building an MP3 player that would hold only approximately the same number of songs a CD could. Instead, they started with a vision, a vision of a great music player that would trigger a market breakthrough. At first, they didn't have the right people to develop the music player, and the necessary components were not available yet either, so they waited, month after month, they scavenged key components that would help them fulfill their vision, they first found a suitable LCD screen and then a rechargeable battery, and finally in February 2001, after a routine meeting with a Japanese supplier, Toshiba, the engineers showed them a new compact hard disc drive with five gigabytes of storage capacity, and said they didn't know what to do with it, but Rubinstein knew immediately, because he and Apple had a vision long before the drive became available. He scored a $10 million check from Jobs that night, and later brought every single one of the 1.8 inch drives Toshiba made. With all the key components in place, Rubinstein assembled the development team.

By then, they had the battery to power the device, the screen to display its contents, an a powerful storage unit that can store a thousand songs. There was only one crucial component missing to complete their vision, the hardware interface for people to quickly browse through their massive music collection on this new music player, and when Phil Schiller revealed his solution during a meeting discussion, the track-wheel, everything immediately clicked, it all made perfect sense. Because everybody on the team shared the same vision, and knew exactly what kinds of capabilities they were after even before they started out looking for technical solutions.

Likewise, Microsoft went through a similar process when it developed the Kinect for its XBox video game console. After the runaway success of the Nintendo Wii, the senior VPs at Microsoft wanted to re-imagine the Xbox. Like the iPod team, they too had a vision, they all knew what they had wanted: motion-tracking controls, facial recognition, speech recognition and backwards compatibility, as their project lead Don Mattrick had framed the challenge "expand gaming to a whole new set of customers" and "get rid of the controller," but no one was exactly sure what it all meant in terms of hardware at the time.

As the team set out to look at all the possible ways to get rid of the controller, they realized that none of the facial recognition technologies Microsoft Research had previously developed would work properly for body tracking, and soon after that they discover that their own technologies alone cannot help them solve the puzzle, they have hit a dead end.

Until finally, at the 2006 Electronic Entertainment Expo in Los Angeles, Alex Kipman, the Kinect's development team lead, discover a startup company based in Tel Aviv, Israel named PrimeSense. What PrimeSense had on display at the expo was a device they had built that can accurately map out an entire room in 3D by measuring changes it can detect in an inferred light beam with encoded patterns. Just like when Rubinstein saw the new Toshiba hard drive, Kipman immediately knew what this technology could do for him.

The discovery of their software solution took place in very similar manner where they serendipitously stumbled upon the works of a computer-vision researcher who too was from outside of Microsoft.

With design driven innovation we have taken a great step forward in solving the innovation dilemma, but using design and vision to steer and drive the progress of technology and innovation still has its own limitations. Verganti's thesis is best used in adding and applying new uses to existing technologies which usually results in market breakthroughs, but when it comes to unearthing breakthrough technologies, design driven innovation can sometimes be unrealistic and even risky. This limitation is also one of main reasons designer are often being criticized by others involved in the innovation process, especially by engineers.

That is, a vision without the necessary enabling technologies can be nothing but an imaginative dream, and dreams don't always come true.

This also explains why despite the various benefits associated with design driven innovations, most radical innovations are still led by engineers. A designer, or an inventor, or anybody else for that matter, can envision the future. One can easily arrive at a vision thirty or forty years before the necessary technologies become available. Chasing a wild idea and develop a revolutionary product may sound exciting, but the consequences can at times be devastating to the financial wellbeing of a product company. Not everyone is comfortable with putting the keys to the success or failure of their future products in the hands of other companies. Imagine if PrimeSense never existed, the Kinect project could have easily been canned for not having a realistic solution.

Companies love good ideas, but they also need them to be affordable. Starting a project from pure vision involves extremely high levels of uncertainties, you can easily burn millions of dollars and still don't have a valid solution. So most people default to the less risky route, develop the technologies first and then hire designers to figure out what they are good for. After all, designers are best at divergent explorations, they can come up with hundreds of ideas in a very short amount of time, but the development of a new technology usually takes years or even decades.

But is this true? Is this seemingly less risky technology before vision approach truly better? I have my doubts, I believe, the best way to innovate ought to be the combination of both approaches. Microsoft supported years of elite research in computer vision, they are in possession of large numbers of relatively good technologies, but when these technologies were confronted with a visionary challenge they proved to be practically useless. The real problem we ought to be dealing with is how to bridge the gap between designerly visions and practical research and engineering, and I think I have found a way.

3. JUSTIFICATIONS

In this chapter, I will walk us through the exquisite relationships between design, technology, human values and different types of innovation through several slightly different perspectives, in the hope of finding a valid direction for developing a refined design process that would be fully aimed at optimizing product company's innovation process.

3.1.Design & Incremental Innovation

A novice user phones the customer service center and asks for instructions to use his newly purchased all-in-one printer to scan a document into his computer and then print a copy. A customer service representative greeted him kindly and offered to help. The representative first walked him through, step by step, the procedures for scanning the document, next he showed him how to process the scanned image in a processing software shipped with the printer to adjust the color and contrast, and finally, he explained thoroughly how to adjust the printing settings and print the document. Everything went smoothly, and in the end the customer was thrilled. However, if you were like me, you probably would ask, "Doesn't an all-in-one printer do photocopies as well?"

That's the situation with designing for incremental innovations. It attempts to address all of the problems present in an existing product, and tries to answer as many customer requests as possible, but in the end, it doesn't inspire anybody, it doesn't show us the better way.

Going back to Don Norman's argument[32] on design research and innovation, he concludes that the most frequent gains in business are results of incremental innovations: trimming cost, improving efficiency, and adding small features all add to a product's competitiveness, and in the midst of all these small, incremental improvements, design plays an important role. It is all correct, from a business perspective, a good product idea has to be able to sustain a business,

[32] Norman. Technology First, Needs Last: the Research-product Gulf.

no business can sustain itself if it keeps developing disruptive technologies and radical innovations that renders its previous domain knowledge and expertise obsolete, and from an engineering perspective, exploiting the maximum potential of components and materials, and pushing their limits to achieve the highest level of efficiency before moving on to newer components and better (usually more expensive) materials with higher capacities is naturally considered to be good engineering practice. The same logic applies to design, taking full advantage of potential capabilities of a product, service or system to better serve customer needs is what designers care about the most. For product companies, until the maximum value per dollar ceiling is reached, there will always be room for incremental innovation.

However there is a flip side too. A good product makes people happy, and if the price is right, good products turn into successful businesses. Consumers don't know if the per dollar value of a product has reached its peak or not, and in all honesty, they don't care either, and in some cases, when a dramatically better solution is available, any small, incremental innovations over the current solution just won't cut it anymore. Consumers want means to fulfill their goals, for the same price, the more fulfilling the tool is, the happier the consumers become and the more likely they will choose the better tool over other competing products. Many people refers to the S-curve[33] when they talk about innovation (Figure3-1). When a new invention is introduced, it usually has many problems at the beginning, its functions maybe ill defined, it may be technically inefficient, as such, there's often huge rooms for improvements. That's when good engineering and good design is most useful because through continuous incremental innovation they help the invention to move up along the S-curve. However, as major flaws are addressed one by one, the product will slowly become saturated and it will be harder and harder to further improve it. At some point, any new incremental innovation will only yield marginal improvements to the value the product holds, and as a result, the competitiveness added by each one of these subsequent incremental innovations would be minimal. Eventually, this

[33] Rogers. Diffusion of Innovations.

incremental approach will become uneconomical to continue, and to attract more customers and further sustain the business a radical shift will be needed.

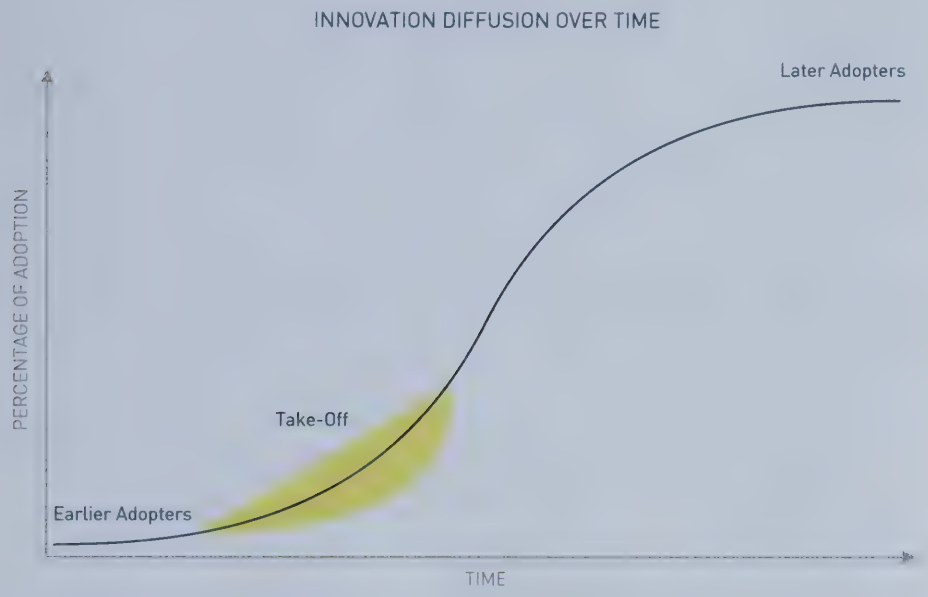


Figure 3-1 Innovation diffusion over time

Incremental innovation, as its name implies, requires the design be carried out based on the previous iteration of an existing product or service, meaning despite designers preaching the importance of human centered design, incremental design is by nature tool centered. Tools are often communicated by functions and features, and functions and features are utilized through operations, tasks and activities [34], therefore design processes and research methods were developed for providing better understanding of usage patterns and user operations, but most emphasize on scrutinizing people using existing solutions, this would in turn prevent designers from looking elsewhere for potentials of a radical product upgrade. So instead of identifying opportunities for radical innovations, more features and functions are added per user requests and market research to add

[34] Norman, Donald A. "Human-centered Design Considered Harmful." Interactions 12.4 (2005): 14-19. Print.

up to the product's per dollar values and to maintain its competitiveness in the marketplace.

This creates many problems. It prevents companies from dealing directly with the challenge of maintaining their innovativeness, instead they would try to work their way around their problems. It also further delays companies in taking necessary actions to take advantage of new emerging market opportunities and technological breakthroughs, even after a competitor has already done so and taken the lead. Think of what other smart phone makers did in response to the introduction of the original iPhone in 2007, some denied the iPhone OS as a superior software platform and tried to simply implement utility applications with similar look and feel as an attempt to catch up with their new competition only to find out later that their existing platform just isn't as sustainable as Apple's iOS counterpart, because although the first iPhone OS had many imperfections, and its original built-in functionalities didn't seem to be much more advanced when compared with other smart phones on the market at the time, its underpinning technologies ensured this new operating system is at the very beginning of a new S-curve, and there are plenty of room for improvements laying ahead, whereas other smart phone operating systems are already approaching the end of their S-curves. Additionally, since many product categories predated human centered design, these products' original features and functions in many cases may not mesh well with people's goals and motivations, and since incremental innovation only improves certain aspects of a product or portions of a service by building upon existing designs one step at a time, on occasions, designers would get caught up in fixing individual problems at a very micro level without really considering the overall structure of the product. After many generations, the purposes of these products would become increasingly fuzzy, making further improvements harder to achieve. Similarly, adding more features to appeal to higher end customers too will render a product growingly complex and less understandable which will in turn complicate further developments.

Donald Norman and Alan Cooper both proposed their own solutions for combating the shortcomings of design for incremental innovation. Norman

suggests[35] designers should put their focus on understanding human activities instead of mere actions and tasks, because the purpose of tools is to be used to support human activities, therefore as Norman claims "Understand the activity, and the device is understandable." More importantly, if a designer understands the deeper underlying requirements of activities, when technology evolves, these understandings would favorably influence the design and improvements of those supporting tools. Likewise, Alan Cooper proposes[36] that designers should go one step further to focus on the reasons why a user performs an activity in the first place. Cooper believes goals are the motivators for people performing activities, and unlike activities and tasks which are transient and change frequently over time as technologies evolve, goals are much more resilient, and change very slowly, if at all. Therefore goals can be used as an anchor in the design process for maintaining cohesion and understandability. Both theory touches on the idea of basing design decisions on more stable and more general factors instead of pivoting around the tool itself, and together they would form the foundation for the theory this thesis presents.

3.2.Design as Problem Solving

> *What this means is that if you have any fact, which you think is really sinister, right, is really obviously a fact which can only point to some sinister underpinnings. Hey, forget it man. Because you can never, on your own, think up all the non-sinister perfectly valid explanations for that fact.*

That's what Josiah "Tink" Thompson, author of the most authoritative chronicle of JFK's assassination, Six Seconds in Dallas, commented in an interview[37] after recapping the legendary tale of the Umbrella Man. Thompson described the peculiarity of spotting a curious person, on a beautiful sunny day, with an open

---

[35] Norman. Human-centered Design Considered Harmful.

[36] Cooper, Alan, Robert Reimann, and Dave Cronin. "Goal-Directed Design." About Face 3: the Essentials of Interaction Design. Indianapolis, IN: Wiley Pub., 2007. Print.

[37] The Umbrella Man. Prod. Errol Morris. The New York Times, 22 Nov. 2011. Web. <http://video.nytimes.com/video/2011/11/21/opinion/100000001183275/the-umbrella-man.html>.

black umbrella, standing by the side of the road under the Stemmons Freeway sign, where John Kennedy was shot and killed in 1963. After Thompson published his finding, the "Umbrella Man" immediately spawned myriad conspiracy theories, some even suspected that the umbrella the man was holding had a gun and an aiming device rigged inside. However, when the Umbrella Man finally came forward and testified in Washington in 1978, people found out that the open umbrella was actually a visual protest at John Kennedy's father, Joseph P. Kennedy's appeasement policies toward Hitler during his tenure as ambassador to Great Britain, and the umbrella was a reference to Neville Chamberlain's umbrella.

What does this have anything to do with design? Let me try to explain. Design is often seen as a problem solving activity where a designer would define a problem or a set of problems and then attempt to solve them. In this process, two things could go wrong, the first, is properly defining the problems, the other one is getting to the right solutions. The problem with these two is that they are both very unreliable. Some may disagree and argue that various design research methods are in place to ensure the outcomes are always objective and truthful, but I would like to point out that in many real world product development situations, there is usually little time allowed for thorough investigations and analysis. Consequently, inaccurate conclusions can be drawn from misleading or simply incomplete information. We make assumptions based on information available to us, but sometimes one missing piece of important information is enough to throw our answers way off. Just like the Umbrella Man case, who would have thought it was a protest, especially since it was not aimed at JFK himself, but at his father instead. Yet once the missing information was revealed, it all suddenly made perfectly valid sense. Problems can be defined from many different perspectives, all can be seemingly justifiable, however if they are defined based on incomplete information, solving these problems may fail to lead companies to their desired results, or worse, diminish the overall competitiveness of their products.

Of course, there is another dimension to design by solving problems. If the goal is incremental improvements, there is no way a designer can know for certain that

by fixing all the problems he or she can possibly find will in fact increase the adoption rate of a product or service. Sometimes, marketers, researchers and designers did all the research and found out exactly why people hated their product, then the designers would fix all of them, but in the end people still hate it. Because there is no set metrics for determining what kinds of problems will have the biggest impact on consumer buying decisions, designers often end up solving trivial problems.

The other drawback with design as problem solving is the problematic divergent exploration approach. There is nothing wrong with the idea of wanting to explore as many alternative solutions as possible before settling down to just one or two of them, the real problem lies in how the exploration is actually being carried out and by whom. Johnson described[38] the phenomenon of slow, partial hunches gradually taking shape in the minds of different people in different places, and eventually only when the two or more partial ideas connect and collide a truly innovative solution can be formed. In product design, delivering a solution to a problem requires both vision as well as implementation. So the question comes around to who should be responsible for figuring out solutions for those proposed design problems, the designers mainly responsible for the visions, or the engineers or programmers responsible for implementing and realizing the visions? When asked this way, the answer seems obvious, it has to be a collaborative effort that involves the brightest minds of both worlds, but again, in reality, it doesn't happen this way.

In places where design has a bigger influence, designers would get together first to conceptualize and brainstorm about what problems needs solving and what creative solutions are out there that can be utilized to conquer the problems, and then this envisioned solution package will be passed on to engineers or programmers to figure out how to actually implement it. At some point, the engineers will come back to the designers and point out certain parts of the solutions cannot be fully implemented and trade off would have to be made. In optimum situations, the designers and engineers will work together to try to

[38] Johnson. Where Good Ideas Come From: the Natural History of Innovation.

redefine the individual technical problems and try to find ways to work around them, but because of the technical nature of these problems, the engineers would usually lead the path in finding alternative solutions this time, with the designers only evaluating the impacts those technical changes would impose on the original design concept until agreements are reached and a revised design is finalized. The problem here, is that as a solution concept moves through the various implementation stages, compromises have to be made and the original idea will gradually get chipped away, bit by bit, and by the end of it, the design would be crippled. In worse situations, the engineers and programmers would start working on the technologies before designers are involved. Since certain technologies cannot be altered once development has started, the design options would be severely limited, which will eventually be reflected in the quality of the final resulting product.

To ensure the value of innovations get delivered one hundred percent to the market and eventually to the customers, this problem defining and problem solving process has to be a truly collaborative activity instead of a linear chain of operations, and there is one company that does just that, Apple Inc. At Apple, the product development process is non-linear, instead of taking the development of a product sequentially through various departments from design to engineering to manufacturing to marketing and to sales and distribution, Apple incorporated a very different approach as what they call "deep collaboration" and "concurrent engineering" where all departments at the company work together in parallel right from the beginning of every project[39]. What this means is that when a vision for a new product is effectively communicated and understood between all parties involved in the delivery of this new product from start to finish, everyone will be able to contribute ideas and solutions that would best serve the requirements for making this vision a reality, be it design or engineering or operations or manufacturing related. Every decision will be directly aimed at the heart of the project, not at some distracting technical setbacks. This also obeys Johnson's law of liquid networks, where partial hunches get connected to give life to truly innovative ideas. Because designers alone do not have the capacity to

[39] Isaacson. Steve Jobs.

anticipate all of the problems that would come up in developing, manufacturing and distributing a product, they should not be put in the position to decide all the solutions to the proposed design problems.

That said, it is unrealistic to suggest that all companies be restructured to mimic Apple's concurrent process. For product designers still struggling in the linear, sequential development reality, changes ought to be taken in the ways of how design problems are be framed, and what roles designers ought to be taking in facilitating the solution finding process.

3.3.Technology Pyramid, Lead-Users & Tool-Chains

Earlier, I noted that technologies are the fundamental building blocks of innovation. It means innovation doesn't happen in a vacuum, but instead it's about creating new things from other things that already exists. Henry Ford once said,

> *I invented nothing new. I simply assembled the discoveries of other men behind whom were centuries of work. Had I worked fifty or ten or even five years before, I would have failed. So it is with every new thing. Progress happens when all the factors that make for it are ready and then it is inevitable. To teach that a comparatively few men are responsible for the greatest forward steps of mankind is the worst sort of nonsense.*

To be more specific, what he meant by "discoveries of other men" are in fact technologies. As Brian Arthur points out in his study of the history and evolution of technology, all technologies, including devices, methods, or process, are means to serve purposes, and all are combinations of existing components, assemblies or subsystems readily available at the time of invention, and since each one of those sub-components serves a purpose, each too can be qualified as a technology[40]. Here, by technology, neither Arthur nor I mean advanced

[40] Arthur. "Questions." The Nature of Technology.

technologies, but simply everything humans ever created as means to fulfill purposes.

For example most modern candles are composed of a solid cylinder or block of wax, usually made of paraffin and acting as solid fuel, and an embedded wick for holding the flame. When lit with fire, it provides a stable, continues and self-sustaining source of light. The candle itself is a piece of technology, as it is a means to provide light and sometimes heat for people, and at the same time, the paraffin wax, and the wick, which is usually a cord, can both exist as standalone components readily to be used for other purposes. Paraffin wax may sometimes be infused in drywalls for help maintaining consistent room temperatures as it melts during the day and solidifies during the night, basketball players also use paraffin wax to keep their hands soft during games, and of course a cord may afford many different ways to be used.

For more complex technologies such as cellphones, there's usually a hierarchy of subassemblies, and sub-technologies, and sub-sub-technologies. The iPhone consists a central logic board assembly as its "brain", with processors, memories and various electronic sub-components; an antenna assembly for handling several different types of wireless signals and feeding information it receives into the logic board for processing and broadcasting data given out by the processor to other devices; two camera modules for capturing images and videos, with one also including an LED flash; a battery that powers the main assembly and other supporting assemblies; an ambient light sensor, an inferred proximity sensor that sends informations gathered from the phone's surroundings to the processing unit; a vibrator motor; an audio assembly; two microphones; a few button assemblies; and a front glass panel touch screen assembly that acts as the main interface between the central processing unit and the users of this device. Each can be seen as a standalone sub-technology. As we dig deeper, into the touch screen assembly, we would find a Gorilla Glass panel, a strip of LED backlight for the LCD screen, and the Multitouch touchscreen itself. Then if we examine it further, inside the touchscreen assembly, there is the LCD display layers, and on top of that, there is a layer of glass substrate, two transparent conductive layers separated by non-conductive separator dots, and a

flexible transparent surface. Finally if we look at the LCD display layers, it consists a light guiding plate, two diffuser film and a prism film, all technologies, all carrying specific purposes to serve the functions of the entire assembly.

Of course, for a design as simple as a candle or as complex as an iPhone to be fully implemented, all necessary components have to be made available first, but the greater implication for designers lies in the fact that technologies are commonly structured in functional groupings and clusters of assemblies and subassemblies, and sub-subassemblies. As Arthur explains[41],

> *Separating technologies into functional groupings also simplifies the process of design. If designers were to work with tens of thousands of individual parts they would drown in a sea of details. But if instead they partition a technology into different building blocks—the arithmetic processing element of a computer, the memory system, the power system—they can hold these in their minds, concentrate on them separately, and see more easily how these larger pieces fit together to contribute to the working of the whole.*

Engineers do this almost automatically, but designers seems to be largely unaware of this pattern in innovation. If it's best for engineers to breakdown the design of a device into separate assemblies and approach each of those individually to keep the implementation of the design manageable, then the process of product design and problem solving should adapt to this approach. Instead of coming up with a series of design problems and seek solutions directly, designers should learn to further deconstruct these main problems into sub-requirements and sub-sub-requirements that are graspable by engineers and developers. It not only creates a collaborative bridge between designers and engineers, but also enforces designers to maintain an integrated and cohesive structure to link all design problems at various hierarchal levels together and keep the design focused.

For example, at the time when candle wicks still required frequent trimming to maintain slower burning and to prevent smoking, a main problem that needs to

---

[41] Arthur. "Combination and Structure." The Nature of Technology.

be solved to make a better candle design would be that the use of candles demands too much care and effort. Designers as usual can dream up all sorts of wacky concepts that attends to this problem, but chances are the designer working on the project doesn't understand the inner workings of how the wax is burned and how the wick is used to support the flame, so in order to make the design plausible, engineers would be involved. At this point, it will be much easier for us to get to the optimum solution if the designer can articulate the ultimate goals behind the activity of trimming the wick, and reframe the original problem and translate it into questions that would motivate and challenge others with the right knowledge and expertise to find ways that would fulfill the sub-requirements of this problem. Since the real goal here is not to find a better way to trim the wick, but to ensure a consistent, steady flame without smoke, with the least amount of efforts required. So a question that would more likely lead us to a practical solution may be reframed as: how can we make the candle burn evenly and prevent it from smoking without needing to trim the wick? When asked this way, the question becomes open enough as to not suggest any specific direction in finding an answer, so that it attracts people from diverse backgrounds to seek solutions from different perspectives, but at the same time, it is still specific enough so that the key requirements can be much better understood by those who attempt to solve the problem. As we now know, the actual solution people came up with was a "self-trimming" wick that was engineered to bend over to the side as it burns, through which the wick would get contact with oxygen and get consumed by the fire—a solution that is not very likely to be conceived and implemented by a designer alone. In other instances of dealing with much more complex design problems, the questions should be carefully divided into separate sub-questions aimed at addressing each sub-problems that are key to solving the main problem.

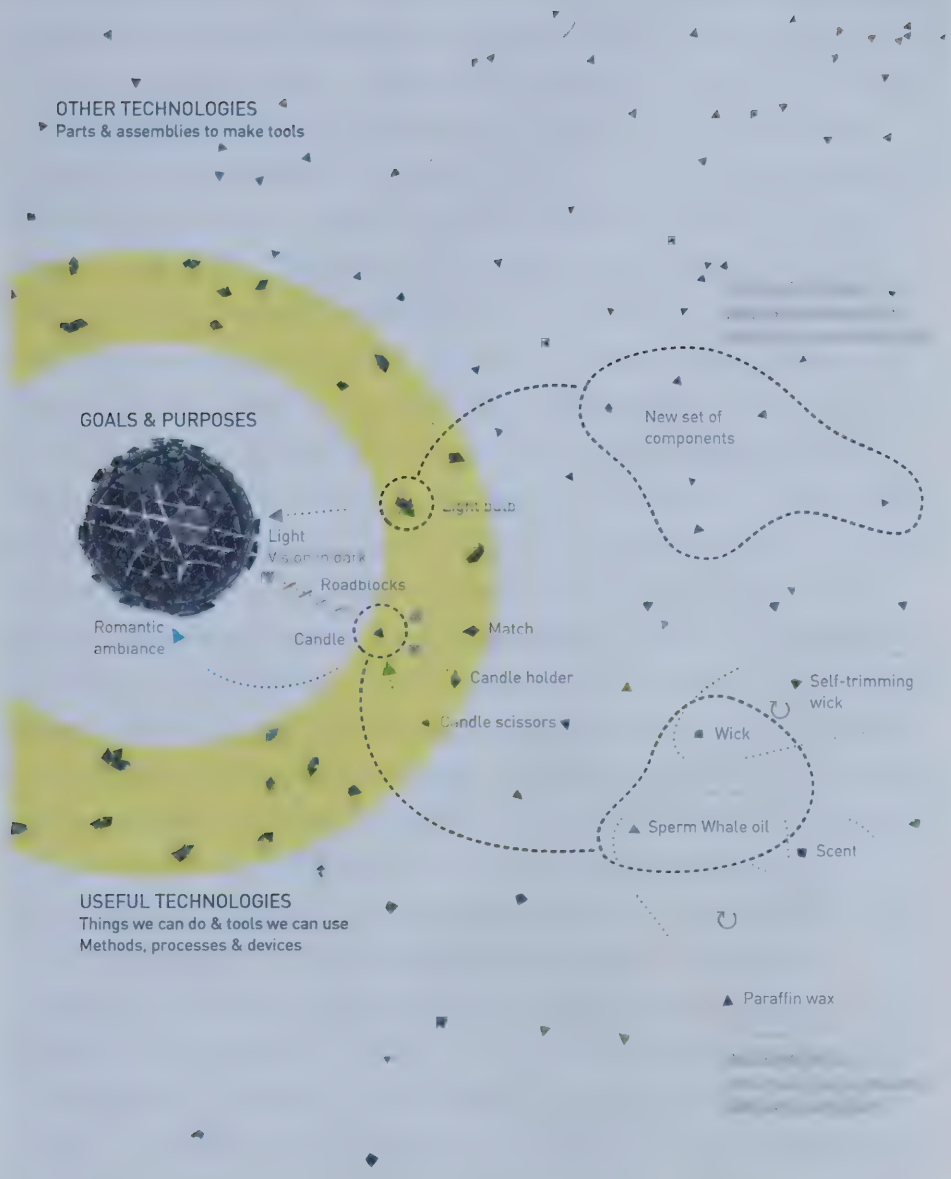


Figure 3-2 Relationships between innovation, goals and purposes, and technology

Furthermore, this grouping structure can also helps us better understand how innovations take place. To help explain the relationships between people, technology and innovation, I came up with this diagram (Figure 3-2). At the very center, there are the ultimate goals and purposes a person wants to attain. These goals are immediately surrounded by all sorts of current technologies that can be used to fulfill these goals, They are usually hand picked by the person based on his personal life experiences from what he believes are useful for helping him achieving his goals, including things he knew that can be done (methods or processes) as well as things he knew that can be used (devices). Among these technologies, some are directly serving this person's needs, while some are used to support the proper operations of other technologies, and between each individual technology and the purpose it serves, there are usually limitations, drawbacks and unavoidable costs, I call them roadblocks. Take the ancient candle as an example, its purpose is to provide light, which in turn satisfies the person's need for seeing in the dark, in between, there are several roadblocks, such as fire hazard, odor, short burning time, flickering light source, smoke, and troublesome excessive wick. To make sure the candle functions properly, several additional technologies are also selected, including matches to light the candle, a candle holder, and a candle scissors to trim the wick. Finally, outside this circle of useful technologies, is the entire universe of all technologies, assemblies and individual components, available, and ready to be used. Among them, there are also those elements used to compose the technologies illustrated inside the useful technologies circle. If we look at it top down from the values to technologies, to supporting technologies, and then to each individual assemblies, subassemblies, parts and components, the whole structure will look something very similar to a pyramid (Figure 3-3) usually with several different products aimed at satisfying the same goals, each assisted by its own set of supporting technologies, and inside each product, there are main assemblies and supporting assemblies, subassemblies, and sub-subassemblies all the way down to each individual component.

Figure 3-3 Technology pyramid

When one or several sub-components or subassemblies of a technology (a product, or service) are tweaked, or replaced by other technologies, without seriously affecting the overall technical structure of the product, we have an incremental innovation. For example when paraffin replaced sperm whale oil as the main ingredient for the solid fuel used by candles, or when a specially engineered wick that bends and burns was incorporated, the design of the candle as a lighting technology was incrementally improved. There are at lease two ways incremental innovations can prove itself valuable and appeal to the person using the product. One is to reduce the number of road blocks, for instance, paraffin wax eliminated the odor from previously used oil when burned. The second is to reduce the dependancies the product has on other technologies, namely a better wick design eliminated the need for candle scissors.

While swapping and refining individual components, occasionally a market breakthrough can be achieved, dramatically increasing the per dollar values the original product offered. In the case of candle making, the discovery of paraffin not only brought many benefits to users but also dramatically reduced the cost of

making candles and made the technology inexpensive and affordable. Another example would be, most candles sold in developed countries today, are dyed and scented, which is the result of a meaning change, from mainly being used only as a light source to something that can also be used to provide a romantic ambiance.

A technological breakthrough is different. It entails taking a completely new set of components, and creating a structurally distinct technology to fulfill a single or a group of related human goals and purposes in a different way from what was used before. For instance, heating a filament in a glass bulb filled with inert gas to a high temperature through electricity and making it glow did exactly the same thing candles had done for humans for thousands of years, but the inner components used is radically different from that of a candle. However, it is important to note here that the individual parts and components used to achieve a technological breakthrough do not necessarily need to be newly developed technologies, and quite the contrary, in many cases, they are usually technologies that have been around for some time, and now borrowed from alternative contexts and reapplied in new domains. Like T. S. Eliot once wrote [42],

> *One of the surest of tests is the way in which a poet borrows. Immature poets imitate; mature poets steal; bad poets deface what they take, and good poets make it into something better, or at least something different. The good poet welds his theft into a whole of feeling which is unique, utterly different from that from which it was torn; the bad poet throws it into something which has no cohesion. A good poet will usually borrow from authors remote in time, or alien in language, or diverse in interest.*

The subtle difference between borrowing and stealing is that when you borrow something, you don't own the thing, and you have to use it as the owner instructs, however if you steal something, you would take ownership and as soon as that happens, you are no longer constrained, and are free to modify it in whatever

---

[42] Eliot, T. S. "Philip Massinger." The Sacred Wood: Essays on Poetry and Criticism. London: Methuen &, 1950. Print.

ways you see fit. The only question is, how do we know what to steal and from where?

Finally, if a technological breakthrough could lead to superior performance in producing values, and/or lower cost for potential adopters, a market breakthrough will eventually be reached through continuous incremental improvements and the technological breakthrough would then become a radical innovation.

Now that we understand the structural differences between incremental innovations and radical innovations, it's time to take a look at why knowing all this is important for designers. Since product design's primary purpose is to foster innovations and help companies stay competitive, understanding what innovation is, and how it comes into being will facilitate designers in making informed decisions during research and the design process, as well as identifying market opportunities for breakthrough innovations.

Regardless of whether designers are designing for radical or incremental innovations, knowing the purposes of why a design subject (a product or a service) exists will help designers determine the goals for their designs, which will in turn guide designers in asking the right questions and defining the right problems from the right perspectives. When changes are made to a product, and sub-components are added or replace with newer technologies, knowing the purposes and requirements of the product will help the design and development team keep their efforts focused.

When specifically designing for incremental improvements, knowing the inner and outer relationships between a product or a service's internal components and its external supporting technologies and the purposes it fulfills will provide extra clarity for designers in determining what kind of improvements will likely lead to greater product attractiveness and customer satisfaction. This will also force designers to think about the design subject holistically. Instead of focusing solely on the product itself, seeing the relationship the product has with its supporting technologies may lead to discoveries of problems that may otherwise be overlooked. For example, investigating into product manufacturing process,

which can be considered a supporting technology, will promote lower production costs, and higher product quality.

Figure 3-2 also reemphasizes why designing for incremental innovation and market breakthroughs is much easier than designing for radical innovation. Incremental innovation mostly deals with established relationships between technologies that are mostly well studied and understood by companies building the product, if any research is done prior or during the design process, it will be mostly within the design and development team's area of expertise, and since the relationships between technologies both internally and externally are established, investigation into those relationships will easily lead to product improvements. In contrast, radical innovation is much harder, as it requires one or several technological breakthroughs which involves technology domains outside of a company's technological competencies. Candle manufactures may be competent in chemistry, but we rarely find a candle maker also shares an interest in electricity. The main challenge for designers is that they are not trained to facilitate the establishment of new connections between a company's existing product domain and other emerging technologies. The answer, I believe, lies in letting the ultimate goals of products and services steer the design and development decisions, because goals and purposes are the only touchpoint between the current existing product approach and possible disruptive future alternatives. Also taking the purpose driven approach, frees designers and engineers from their old product mantra, and opens their minds to both incremental and radical solutions, so as soon as a relevant technological breakthrough is discovered, the company can quickly take the initiative in securing the technology and related talents and expand its knowledge base to take advantage of the new technology ahead of their competitions.

Designers' role in promoting radical innovation is very different from that of researchers and engineers. Since it is the competitive advantages that companies are after, commercializing technological breakthroughs that have promising potentials should be designer's main priority, not pushing for technological developments that can lead to breakthroughs, because it typically would take a very long time for any breakthrough technology to be refined to a

state that can be successfully commercialized. Therefore, spotting promising alternative solutions is key to designing for radical innovation. But how are designers supposed to do this exactly?

I suggest adapting an excellent strategy originally developed for marketing research, which is aimed at innovation in general, by Dr. Eric von Hippel. In his research, he demonstrated[43] that a very large body of radical innovations are initially developed by users (individuals or user firms), not manufacturers. von Hippel suggests, breakthrough innovations are heavily motivated by stronger than average needs for empowering tools to achieve pressing objectives. Those who exhibit such needs will be greatly incentivized, much more than average consumers, if a solution is developed. Manufacturers don't pay attention to satisfying those needs because they are among the rarities in the market, niches, and don't hold any significant promise for short term return on investments. As a result, if a person is among the few that want something special so badly, their best and possibly only option would be to innovate for themselves, and von Hippel calls them lead-users.

According to von Hippel,

> *...lead users are defined as members of a user population having two distinguishing characteristics: (1) They are at the leading edge of an important market trend(s), and so are currently experiencing needs that will later be experienced by many users in that market. (2) They anticipate relatively high benefits from obtaining a solution to their needs, and so may innovate.*

The first characteristic von Hippel outlined is largely irrelevant to our discussion, as I believe market trends can be identified through study of goals and activities instead, but the second characteristic carries great implications for solving our solution finding dilemma. Because my goal is to develop a design process that encourages designers to approach design challenges in ways independent of any existing tools and solutions, and identify alternatives for achieving better results based on the goals and purposes the solution fulfills, this lead-user model can be

[43] von Hippel. Democratizing Innovation.

used as a compass for pointing designers into the right directions and take designers to places where they wouldn't normally consider when looking for solutions in their current divergent thinking process.

Since design problems are broken up into hierarchies of sub-problems, defined not by functions and features, which are very limiting as they suggest solutions themselves, but by requirements to fulfill certain goals and purposes, which can also be seen as legitimate engineering needs, if we can identify and locate lead-users sharing the same or similar needs, we could dramatically increased the chances of finding better solutions to the whole problem through radical innovation or one or several sub-problems through incremental innovations.

For instance, if one wants to design a wall clock that can be read easily at night in the dark, instead of aimlessly brainstorming about all the possibilities for developing a viable solution from the ground up, identifying lead-users with similar needs may prove to be a less divergent, but much more effective option. Recognizing the possibilities that people elsewhere may have had similar problems and thought hard for solutions would almost inevitably lead the designer to a well curated selection of proven technologies used for similar purposes such as various gauges and instruments found in most modern automobiles and airplanes today, and allow the designer to confidently select the most appropriate technology for designing his new clock while standing on the shoulders of those before him.

Before I continue on to the next section, there is one more thing I need to clarify. I had kept the concepts of goals, values, purposes and product visions murky during discussions in the previous parts of this thesis, and now I would like to take a closer look, and tie them up in a bigger concept, tool-chains (think food-chains). In this section, I mentioned several examples involving products directly serving human values and purposes, but in reality, more products and services were created to support the purposes of other products, not direct human values. So when I talk about designing a product to satisfy a goal or a purpose, it does not necessarily mean serving a purpose that has direct value to people. Tools exist between a person and the intangible things he values. A tool itself has no

value, its values are reflected in its ability to empower human beings to reach intangible values. Yet all tools have their own limitations, and complications, and they would in turn limit the tools' capabilities in bringing people closer to values. So in reality, tools alone can never fully satisfy people's desire to attain values, there will always be costs associated, and just like products are made out of internal parts and assemblies that supports one another, the hierarchy extends in the other way towards the outside of products as well, in the sense that almost every product, and every service all has a purpose to serve inside a larger system, and they all sit at various points of a string similar to a food chain, and human values would always be positioned at the very top of that chain.

One of the values that mostly everyone shares is the capturing, sharing and reminiscence of experiences, important moments, and precious memories. Throughout history, there has existed several important food-chains to serve as the bridge between people and this value (Figure 3-4). Before the invention of camera, paintings were used to visually record historical moments, they required skilled artists, a whole lot of art supplies, and a very long time to complete a painting, and only the richest can afford it, as a result, the quality and capability of this chain of tools was very limited in fulfilling this particular purpose. When photography became popular, the tool-chain took a radical shift. The new tools enabled the instant capturing of events, and greatly decreased the turnaround time, and the resulting photographs took people one step closer to what they wanted. But the tools too had their limitations, people relied on trained photographer to have their pictures taken, and the equipments were clunky and expensive. Then consumer cameras came along and got rid of the need for the photographers, and made the cameras affordable and easy to carry around. Suddenly, snapping a picture of your kids at a birthday party became a breeze. But still there were a lot of things you need to do between the moment the picture was captured, to the time your family and friends got to see it. That was all changed again when digital cameras took over, the images instantly appeared in front of you the second you pushed the shutter button on your camera, and photos were stored, viewed and shared digitally. Now we are in the age of the internet, pictures can be freely shared and "liked" by millions of people online,

around the globe, merely seconds after they were taken. With every radical shift, people have inched closer to fully embracing the true values behind all those tools created, but each time the tool-chain reboots, some products would be rendered irrelevant, like film for cameras.

When designing products, designers need to know exactly where their product is positioned along various tool-chains, and how many steps is the product is away from serving any real human purposes. Seeing the bigger picture helps designers to spot opportunities for developing more streamlined products by integrating technologies that are in front and behind it on the tool-chain; it also makes companies more vigilant of the dangers of being cannibalized by newer entrant technologies. One of the reasons Apple decided to push forward in developing a mobile phone was because they realized the phones were starting to become a much more versatile device which were gaining a lot of new capabilities, and they feared that if phones start to integrate digital music players, it will cannibalize the company's most successful product line, the iPods.

Knowing where the product belongs has many other benefits. For starters, human centered design aims at figuring out the ultimate needs, goals, and requirements hidden behind a product and using them as guidelines for improving the current design. However, once we acknowledge that not all products are designed to serve human needs and values directly, we would begin to question the appropriateness of this one size fits all approach. In fact, we can see designers frequently running into all kinds of problems when trying to define design problems using this human centric approach, so frequent, they even borrowed a name for it - wicked problems. Since a product is usually positioned in the middle of a tool-chain, when attempting to identify the purposes of the product, we would end up bumping into its various higher-level parent-purposes, and eventually arriving at the central human values supported by the tool-chain. In truth, the problems discovered would mostly be based on these purposes found at each different levels, so technically, they would have all been correct, but not realizing the relationships between these problems can sometimes make the problem defining process very confusing for designers.

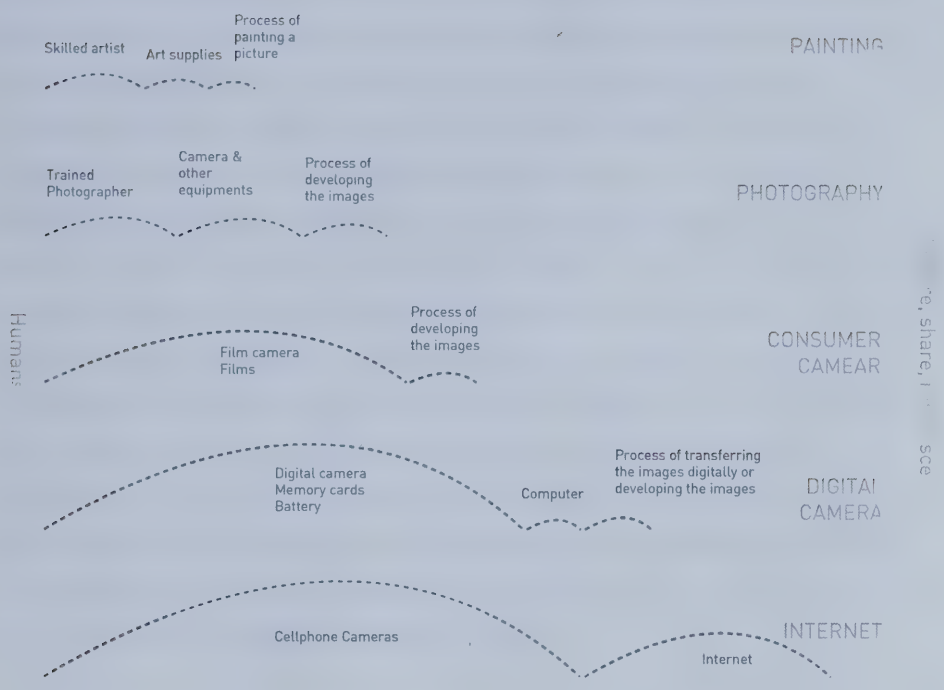


Figure 3-4 Tools for visually capturing important moments

3.4.Networks and Branches

In reality, trying to pin point exactly where a product fits among all other related technologies is much harder than it seems, because in the real world, it would not be a couple of simple linear chains that we would be looking at when dealing with a real design challenge, it will be a complex, interconnected network of products, services and technologies instead. The most important lesson a designer should keep in mind is that whenever there is a set of values, there will always be multiple parallel tool-chains aimed at attending to the very same ends. The closer your tool-chain can get people to the same values, the better chance your product would have in competing against your competitions for the crown of superior solution, and the less likely your product would be cannibalized by more integrated, more powerful alternatives.

In dealing with tool-chains and tool-networks the same rules for designing for incremental innovation through optimization of internal assemblies and parts still apply. Improving internal components can help eliminate external roadblocks faced by an individual product or service, likewise, improving the overall performance of a product can benefit the entire tool-chain and tool-network if done properly. Similarly, making a product or service more integrated by reducing its dependencies on the support of other products or services offered by other companies can give a product company more control over relevant tool-chains and tool-networks, therefore making it much easier to target specific purposes and customer values. In the end, the overriding strategy would be to design bridges that extends further towards the things people value the most, and by slowly integrating functions and features offered by other dependent and parent technologies, designers should gradually lead the products towards the values end on the tool-chain, because the closer the product is to the values, the more significant and indispensable it will become.

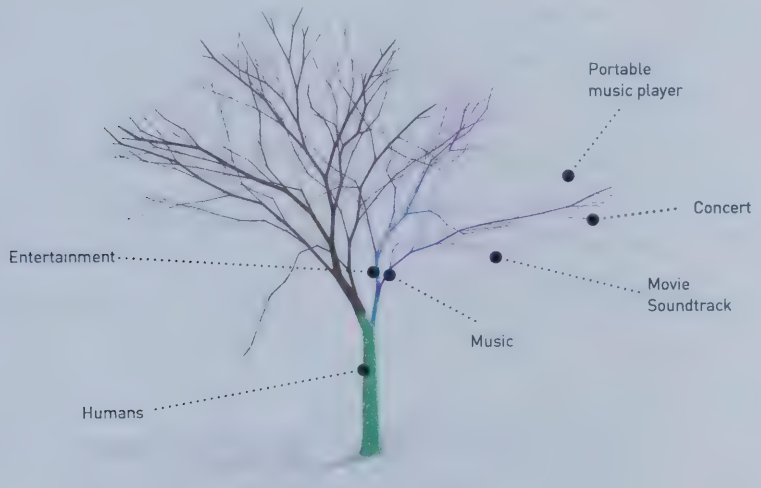


Figure 3-5 Tree of values and products

To better understand the interdependencies between different products and technologies inside the tool-network with tool-chains intersecting each other, we can try to look at it in a slightly different way, and see the relationships as being structured like a tree instead. With humans being the trunk of the tree, each scaffold branch would be a collection of closely related values, for instance, everything related to getting entertained, and each lateral branch will be a sub-collection of values, such as being enjoying music, and finally each twig will be a product or service attending to very same sub-collection of values in slightly different ways, for example, it could be a portable music player, or live performance in a concert, or it could be a movie soundtrack.

When we look at it this way, it opens up new opportunities for innovating. Aside from attempting to inch further towards the values that your current product is attending to, it would also make sense to aim your designs at integrating other qualities of other products or services on adjacent twigs and sometimes even lateral branches your original product neighbors. Because the more integrated you become, the tighter control you would have over the balance of each individual aspects of your service, and the fuller the experience you would be able to lend to your customers. Take a look around, you will be surprised by how many examples you can find: iTunes store expanding from only selling musics to offering a wide selection of contents for entertainments, movies, TV shows, games, books and even radio stations and podcasts; Adobe Creative Suite applications providing tools for facilitating a full gamut of creative practices; and Ikea stores selling kitchenwares as well as recipes and groceries.

3.5.Time, Foundation Changes & Opportunities

As I have described earlier, new products and services, as technologies, are remixes of existing technologies. Existing technologies inspire new connections, and new combinations, and encourage explorations of the adjacent possibles, and it is through these explorations, new opportunities are discovered, and new

breakthroughs are achieved. Yet, in my previous discussions, I've left out one important variable, time.

Obviously, nothing stands still, new technologies are only remixes of what is available at the time of their creation. Yet, as time progresses, the pool of available parts will receive frequent updates. Newer combinations are constantly being added into the mix and as they slowly take the center stage, older parts fades into the background. Although new designs are being inspired by existing technologies, they are also being limited by the boundaries of the adjacent possibles. Try designing a tool for the same purpose at different points in time, the solutions could turn out to be drastically different. Charles Babbage's Analytical Engine is considered to be the world's first programmable computer, but since it was conceived in the 1830s, way ahead of the electronic age, his design was purely mechanical and insanely complex, and because of that, the machine was never built.[44]

Designers at incumbent companies need to be made aware of the foundation changes caused by the evolution of technologies over time. A product is a means to an end, and the design should always be focused on improving the means, not improving the product itself. As new technologies become available, the building blocks and foundations for creating products change, newer products would be made possible as better tools for providing the means. Failing in identifying new opportunities may eventually cause a company to loose its competitive edge.

When new technologies get introduced in different domains, they not only open up new doors leading to new possibilities in their own domains, their effects also get rippled into other domains. Since new designs are pieced together through combinations of existing technologies by taking advantage of unique qualities of each individual parts, sometimes, other characteristics of these parts would also get carried forward into the new inventions. Designers have been fiddling with this notion and trying to take advantage of it visually for years, and the familiar terminology used to describe it is "affordance." Despite the dispute over the meaning of this term, I found the definition by Donald Norman from his 1998

---

[44] "Analytical Engine." Wikipedia. Web. <http://en.wikipedia.org/wiki/Analytical_Engine>.

book "The Design of Everyday Things" best suits the context of this discussion. Norman writes[45],

> *...the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used.*

In most cases, designers would be carefully manipulating the final visual representations of their designs to accentuate and communicate the useful affordances of a product and make sure their designs would help align designer's intentions with user's mental models through people's perceived affordances. But when it comes to designing for innovation, it is usually those unintentionally inherited properties (actual affordances) that inspires unexpected new uses of technologies, namely, through exaptation. For example, Willis Carrier invented the modern air conditioner by taking advantage of the cooling side effects resulted in his earlier invention aimed at dehumidifying air through cooling the air to the dew-point using chilled water, an invention originally made for manipulating humidity, not temperature.

Adaptation and exaptation happens when an inventor sees past the perceived affordances and the intended functionalities of a design, and draws a new connection between some unexpected actual affordances and his or her personal life experiences. This is especially important for designers working in entrepreneurial entrant companies where figuring out breakthrough uses of novel technologies is pivotal.

3.6.Metrics

Of all the things designers can do to help make product companies more innovative, such as letting goals and purposes drive the solution finding process, eliminating road blocks, reducing dependencies, integrating related technologies, expanding target values, and identifying newer or better suitable

[45] Norman, Donald A. The Design of Everyday Things. London: MIT, 1998. Print.

alternative technologies, how does one know how to prioritize and coordinate design decisions to bring out the best possible result? Furthermore, how does a designer prove to the rest of the company, including executives, managers, engineers and marketers, that the decisions are indeed being made in the best interests of the product and the company at large, and finally, how does one measure the impact and the result of all those design decisions?

The answer is quite simple, aim at building great products, do whatever it takes to aid the adoption and diffusion process, and let marketshare and customer loyalty prove the rest.

3.6.1.The Cause of the System

I say designers are useful to product companies because design helps companies innovate, and innovation allows companies to differentiate themselves from other companies competing in the same markets; but what are the causes of those product companies? Why do people need them or pay them for their products and services?

Companies exist and thrive not because the founders wanted to make money. Being incentivized is no doubt a motivator, but it's not the cause. Products' values derive from their abilities to empower human beings to appease their desires, and a product company's value is reflected in its capacity to continuously provide better tools for improving and enlarging human capabilities. That's why, in the long run, that building great products that truly enhances people's lives is always more important than maximizing profits at the expense of product quality. On the other hand, it makes no sense for anyone to keep building superior tools, if what they built is not adopted, put to use, and serving the values they were designed to serve. So aside from concentrating on conceiving ideas and concepts for better products and services that empower human beings, designers also need to take into account how their designs are perceived by potential adopters. This could be even more important than building great products, because in the end, it's the

results that matter, not the intent. If empowering human beings is what makes products valuable, what good does a product do if it doesn't get adopted for use?

Why was the Palm Pilot so successful? Some argued it was the simplicity, because it only had a handful of core functionalities, some say it was the form factor, because it was small enough to fit into your pocket but large enough for interacting well with its contents, and some say it was the Graffiti handwriting input recognition technology, they were all right. Those features made the Palm Pilot a great product for that time, but if you do some digging[46], and look at some of the other products that were also already on the market when the Pilot came out, you would be surprised that many of those products all had very similar functionalities. So what differentiated the Palm Pilot from all of its other competitors? I would say, it was because the team that built the Pilot at Palm recognized the importance of understanding the common perceptions of PDAs among potential adopters, and went the extra mile to address their concerns and uncertainties.

During the 1990s, after the home run success of the personal computers in revolutionizing office automation, having a smaller, less sophisticated digital device that a business person can carry along all day which can act as a personal digital assistant that stores all the important informations including contacts, calendars, to do lists and memos just seemed inevitable. Yet, after multiple attempts in trying to establish this new market, almost everyone failed. Companies making PDAs scrambled in competing against each other, trying to differentiate themselves, but no one seem to be able to figure out what the real holdup was, and then came the Pilot, with HotSync.

What HotSync did for the Pilot was really simple, it took out all the insecurities and uncertainties anybody had with the idea of adopting a PDA, and on top of that, it made using a PDA an integrated experience with the existing computerized office automation system. To put it simply, it made a PDA a lot more valuable.

---

[46] Buxton Collection. Microsoft. Web. <http://research.microsoft.com/en-us/um/people/bibuxton/buxtoncollection/browse.aspx>.

Consider the PDAs that came before the Pilot, they were all standalone products. To computer companies, they were ingenious, but to average business persons, they were just a new alternative solution, competing against their briefcases and the address books, and memo pads within. Feature wise, they were all the same, the PDAs promised exactly what the old technologies already do well, and the only arguably advantage it had was that it was an integrated product, and even that got hindered by their price tags. They were not worthy of the investments, and just like the briefcases, if the person ever looses it, everything would be gone, all the time and efforts he had spent on inputing all the data will be gone with it too. HotSync fixed all that, it made the initial data inputting unnecessary as you can sync-input everything you already have from your computer, and because you can backup all the information by pushing just one button, it made it like you can photocopy all of your address book entries, your calendars, and your memos in just a few seconds and you will never need to worry about loosing valuable informations again. HotSync made the Palm Pilot an indisputable superior alternative to the old school briefcases and other PDAs on the market.

3.6.2.Measurement of Success

How do we know if a design was a success or a failure then? Design critics, journalists and bloggers write about good designs and bad designs all the time, they clearly seem to have some kind of metrics for measuring the qualities of designs, but are they always accurate? A glance into the archives of various influential design blogs will answer the question for itself. Look for all the super stars, and award winners from last year or the year before, and ask yourself, how many of them are still selling well today, if at all, how many of them actually made a dent in the universe? Not too many.

To a product company, no matter how well designed a product is, if it doesn't perform well on the market, it's a failure. It doesn't matter who's at fault When things fall flat, after spending months, and sometimes even years designing and developing a new product, if the final outcome isn't accepted by the potential

customers, all the efforts and resources invested, would have all gone to waste. Well designed products don't always succeed, and quite the contrary, they fail more often than they succeed. Eleven years after the success of the Palm Pilot, the company launched its new generation of mobile device, the Palm Pre in 2009. It was very well designed, and had many innovative features. The design team took the values of their customers at heart, and its WebOS software interface design was praised as even more considerate than the hottest product on the market at the time, the iPhone OS, but in the end, it failed, and Palm was bought by HP in 2010. Shortly after introducing a series of new WebOS devices including an iPad competitor, HP pulled off a fire sale and sold out all the remaining TouchPad inventories, and halted all WebOS related developments. Were the Pre and the WebOS bad designs? Hardly, but some part of it obviously wasn't good enough, and most people were clueless.

Of course, many things can go awry during the development of a new product, and in many cases, it is not the designers to blame, bad timing, inadequate marketing efforts, inappropriate business decisions can all cause a product to fail. However, there is a very important lesson all product designers need to learn, that is, just by designing a great product, the world will not beat a path to your door. Apart from enhancing a product's performance and functionalities, and streamlining it's user experience, ensuring it's commercial success can be equally as important, if not more. Good designers know how to deliver superior quality products, great designers understand how to successfully commercialized their ideas. In the next chapter, I will take an in-depth look at some of the key factors that affect the adoption/rejection and diffusion of new ideas, as well as the important implications they have for designing commercially successful products and services.

4. METHODS & IMPLEMENTATION

After examining the relationships between design and innovation for building successful products and companies. This chapter will be focused on developing and proposing a set of workable design methods and principles to promote better integration of design in the product innovation process. The four major principles of designing for innovation as I will explain in full details throughout this chapter are as follows:

1. Let technology do its own thing;

2. Start with why, not what;

3. Every design should be a first generation; and

4. Design with adoption in mind.

To assess the practicality of the proposed methods and principles, a design project was carried out as a case study, and the subject was an iPhone application, based on a new voice recognition algorithm developed by a couple of software engineers based in Seattle Washington in the United States. The aim of this design project was to test and determine whether by taking a different mindset specifically optimized for innovation, will result in a more robust product that can offer better customer satisfaction and faster product adoption and diffusion.

4.1.Let Technology Evolve on Its Own

Technological breakthroughs happen through careful and gradual exploration of adjacent possibles, the planned and unexpected collisions of ideas in liquid networks. They first exist as slow hunches before they can be fully developed and implemented, and sometimes, they pop up unannounced as serendipitous discoveries and results of unexpected errors.[47] Because new technologies are

[47] Johnson. Where Good Ideas Come From: the Natural History of Innovation.

built upon hundreds of millions of prior discoveries and technologies,[48] it would be extremely difficult to accurately predict when and where the next promising new technology will come into existence. Therefore, instead of trying to use design as a tool to drive the development of future, nonexistent technologies, it would be much more justifiable to allow technology evolve freely on its own and focus major design and development efforts on the applications and recombinations of currently available and commercially viable technologies.

Although many technological breakthroughs were driven by visionaries, many more radical innovations were inspired by and adapted from technological breakthroughs. History shows[49] innovations with the biggest impact on human societies always arrive years after the initial technological breakthroughs. Innovation, unlike breakthroughs, is always a long and cumulative process that never happens overnight. It makes sense for research institutions to explore the universe of infinite possibilities made available through countless ways of recombination and adaptation of existing technologies; but for product centric companies and organizations, it is always the incremental improvements of existing products, and commercialization of promising emerging technologies that holds the key to their future success.

What is important for designers and the product companies they work for, is that when a technology becomes mature enough to be implemented in an actual product, they need to take the initiative to make sure they are among the first ones taking advantage of it. For incumbents, this means always on the look out for new technologies relevant to their business and product strategies. This is not as hard as it may seem, since new technologies take a long time to mature. For entrants, this means ignoring the cliche, and identify hidden potentials of novel technologies and innovate through transformation and exaptation.

This iPhone application project falls into the latter camp. Back in June 2011, I was approached by a couple of software developers and offered a job to help them design an accent reduction application for the iPhone and iPod touch based

[48] Arthur. The Nature of Technology.

[49] Rogers. Diffusion of Innovations.

on a voice recognition and comparison algorithm they are developing. I was in the middle of developing this design process aimed at boosting the success rate of product innovations and was eager to test out my theories. Since their project seemed to suit my requirements well for a lab rat, I gladly accepted.

4.2.Start With Why, Not What

When the developers first approached me, they came with a plan, they told me they wanted an English training application which lets users read articles and scores their pronunciation through recordings, and in the end it generates an image for each user resembling a certificate with a score and the user's name which can be saved or published online. All they wanted was a pretty user interface. So during our first meeting, I explained to them I really admire their technology, and I would love to help them design it right, but for me to do that, we have to go back to the drawing board, and start the design over from scratch, because when working with a new technology like this, the easiest mistake you can make is to start out without knowing why your technology exists, and why would people need it. By the end of the meeting they relented.

It is easy to see how a new technology can make an existing product incrementally better, and thanks to human centered design, more and more breakthrough technologies are being applied to places where they can make the greatest impact on user experiences. There is an old saying in Chinese:"take the best steel for the blade, the advantage of its force lies in the edge." In product design, this means taking the best technology and use it at the interface between your product and the values it helps people obtain, which is the very touchpoint at the top the technology pyramid of your product. However the problem is, the technology pyramid is actually an inverted one (Figure 4-1), because each supporting technology was selected based on the needs of its higher level technology, therefore if we try to take out the technology at the very tip of the pyramid, and flip the whole thing 180 degrees, the whole structure will collapse. Of course, in reality this doesn't really happen, engineers are smart enough to

carefully make the swap without causing system wide turbulence, but the results as you can imagine, are always problematic. Touchscreen technologies were adopted by computer makers for years as an alternative to the mouse-cursor interface, but they never worked well for computer users because everything else in the computer, the hardwares and the applications, were all designed based on the characteristics of the mouse, thus replacing the mouse with a touchscreen interface would in fact require a system wide redesign, but of course, nobody realized it until the iPad was introduced. What this tells us, is that when dealing with breakthrough technologies, although the product idea maybe inspired by earlier, more primitive products and technologies, when the project starts, it is critical to remember, the design process should always start with the purpose, not the features and functions that can be taken from earlier products, because our designs can be easily biased by our experiences with existing products, solutions, and technologies. Luckily for our project, the purpose was quite obvious—helping people reduce their accent.

Figure 4-1 Inverted technology pyramid

4.2.1.Affordances of Technologies

Some say designers don't get to decide what products to design, because when a project starts, the decision has already been made, and it is the same with this iPhone application project; and in this case, I believe even their core technology—the voice recognition algorithm, was specifically developed for their original objective. Nevertheless, I decided to push my luck a bit further. In the hope of finding an opportunity for adapting the technology to different, and maybe even better uses, the first question I asked our team was, what does our technology do, what are its capabilities, what actual, not perceived, affordances does it have.

After peeling away all the features they wanted, what was left was an algorithm capable of three things:

1. It can analyze recorded sounds and compare it alphabetically against a pre-recorded, original "master" soundtrack.

2. It can score the recording based on its deviations from the original sound, so it can tell people how good or bad their performances are.

3. It can visually demonstrate, through comparison of two waveform graphs overlapping each other, where and how the two sounds are different, so people will know where improvements are needed.

Next, I challenged the team to come up with different scenarios based on their experiences where people might have a need for amplifying their capabilities for detecting minor differences in sounds, and in the end, we arrived at three different situations where these technologies can be very useful in helping people achieving their desired values. The first, is vocal and music training, the second, is communicating with dogs, and the third is accent training. The team agreed all three alternatives have potentials in becoming a profitable product. Although no market research was conducted to confirm that, the team expressed keen interest in adding them into their future development plans.

Since the current algorithm was specifically optimized for voice detection and recognition in English only at the moment, we decided our first application

should still be a tool for accent training. However, apart from their initial plan, I proposed a slightly different direction the project could take, instead of using the application as a training tool for English learners, we could make an accent training tool targeted directly at the English speaking market. The application can be used as a coaching tool for teaching people how to mimic different accents, and it would be more of an entertainment application than of an educational one. Again, this got the team extremely excited, and we immediately decided this is what our next application should be once the developers can program in some accent recognition capabilities.

This experiment provided us a glimpse into the possibilities of exploring best use scenarios for breakthrough technologies by creating connections between the actual affordances of technologies and human life experiences.

4.2.2.Let Human Values Drive Technology Selection

When designing a new product or refining an existing one, focusing on what people can gain from using the design is very important. The purposes of the product should drive all the decision making process, and the selection of supporting technologies.

Because technologies are indispensable building blocks for making new products and services, all the important purposes of the product should be properly and effectively communicated to and understood by not only designers but programmers and engineers as well. As mentioned in the previous section, it would be particularly beneficial if a team of designers and engineers is able to achieve a mutual understanding on what core capabilities a product should be providing to its users early on in the design and development process. This way instead of passively working around technical challenges to implement features specified by the designers, the engineers, who are usually more technically capable, would become better involved in identifying design challenges and in seeking or developing suitable technologies for completing the product before any significant design decisions are made. In the case of our project, the core

functionality we agreed on is to provide a fun and easy way to help people mimic various accents when speaking English. To achieve this goal, our developers suggested an extra component to our existing voice analysis algorithm for detecting different accents should be developed separately, and explained how the new component would fit into the existing structure of the program. This proves that when a vision is clearly articulated in ways that an engineer can comprehend, it would drive the engineer to seek solutions to design problems.

The direct purpose of our application is to help people reduce their accent, but it obviously does not mark the end of a tool-chain. Reducing accent is only a means for people to fulfill other purposes, such as to sound authentic, which may in turn lead to even greater purposes including less communication barriers, more social opportunities, better jobs, greater self-confidence... If there ever comes a day that the makers of this application want to expand the capabilities of their product, a look into other requirements for sounding authentic, or gaining better communication skills may present further opportunities, and these new requirement will drive a new round of selections for suitable technologies.

4.3.Every Design Should be a First Generation

The other benefit of starting a design project by first identifying the purposes of the subject is that all future revisions or improvements to the subject can be based on the initial findings. Having a clear understanding of what a product is initially designed for will guide the future development efforts in adding to its original values not distracting from it. Even when the original inventors have already left the team, the cause of the product can still be safely preserved.

When Volkswagen started working on the design of their third generation 2012 Beetle car, they made a very significant decision in how they should approach this redesign, and they decided to put an original (not the second generation) first generation Beetle in their design studio where the designers worked on the new

design. When asked about why they made this decision, their vice president of product marketing and strategy, Rainer Michel said:[50]

> *What we did in '98 was the right car for that time, but this one is more true to the design of the original.*

Michel explained that they wanted to make sure they would always return to the source when redesigning the iconic Beetle, and each time they might go in different directions, but in the end, they would all be based on the original design, not the previous generation, so every future VW Beetle will be a second-generation design.

This is a great strategy for preventing Volkswagen from slowly deviating away from the true essence of what makes the Beetle a great car, and it can also be applied in product design for preventing the product teams from loosing their focus in the process of countless iterations. Technology is always evolving as time changes, the pool of available parts is constantly updating. Basing every redesign, radical or incremental, on the purposes of the product, and making each one a first generation design can help companies prevent the possibilities of being biased by solutions used for previous generations of the product. When new technologies more suitable for serving the core purposes becomes available, companies will be more capable of identifying the opportunities and taking advantage of them quickly. With each new iteration, more can be learned about the purposes of the product, and more understandings about the cause will be added back into the knowledge base for the next redesign.

Since the Accent training application is a true first generation design, we were not able to test the usefulness of this "first generation" principle, however, we did carefully investigated and documented the purposes of our product for guiding our future development plans.

---

[50] Ramsey, Jonathon. "Every New VW Beetle Will Be a Second-generation Design." Autoblog, 22 Apr. 2011. Web. <http://www.autoblog.com/2011/04/22/new-york-2011-every-new-vw-beetle-will-be-a-second-generation-d/>.

4.4.Design with Adoption in Mind

Our aim for this project was not to make an application that gets featured on popular technology or design blogs for its eye popping features (although they might help us in getting the initial exposure), but instead, we made extra sure that we were creating an application that can truly benefit people in helping them get what they want; that being said, as an entrant in the market of language training devices, our biggest challenge was not how we can make a superior tool, but how to convince people of that, and how we can design our application so that it can enchant people and attract them to adopt our solution. As I have touched upon in earlier chapters, a truly well-designed product is never about its each solitary features, but instead, its prominence lies behind the level of cohesion existing between its each individual component, all acting together towards enriching the same set of values, without distraction from superfluous gimmicks. Killer features may help ease the marketing efforts of products, and are essential to proof of concept demos, but they do not necessarily make a particularly weak product any stronger. Great products offer people alternative paths for achieving more values with less efforts while also ensuring the transition stress-free. That said, it is not easy to have people recognize the superiority of carefully considered products when most consumers don't even know what they should be expecting in their next purchase, especially when there are many competing products with similar specifications in sight. As a result, designing not only what products can do, but also how consumers would perceive them is becoming increasingly important.

Does that mean we should now all start researching about what affects peoples' perceptions of new products, and how those perceptions will eventually influence the purchase decision process? I propose otherwise. As I have previously stressed that new technologies are built on top of existing technologies, and that lead-users tend to be a general source of leading edge solutions, apparently, there has already been considerable amount of prior research done on subjects related to technology adoption and innovation diffusion by researchers and practitioners from outside of the design community, which means if we choose to investigate the possibilities of optimizing design processes for better customer

perception and higher adoption rate, there is already enough existing theories for us to start building upon.

By briefly surveying existing related theories, I discovered there are a variety of models[51] used in both practical and academic settings for understanding innovation adoption and diffusion processes as well as predicting the successful use and spread of innovations and technologies. In practical use they are mostly being applied in business contexts and have been especially influential in the field of marketing; however I was surprised to find that they haven't gained any significant attention in the design and engineering communities, considering they are the ones chiefly responsible for the design and implementation of new products.

Of all the different elements found to influence the decision making process of adopting or rejecting an innovation, I have categorized them into four main constructs which needs to be carefully addressed to ease designs' adoption barriers, and to increase their chances of gaining mass market acceptance. These four constructs are mainly based on the Unified Theory of Acceptance and Use of Technology(UTAUT), which was originally developed to be used as "a useful tool for managers needing to assess the likelihood of success for new technology introductions and helps them understand the drivers of acceptance in order to proactively design interventions (including training, marketing, etc.) targeted at populations of users that may be less inclined to adopt and use new systems."[52] They were adapted in this thesis as key guidelines for designers designing and developing products optimized for adoption and diffusion. The four constructs are Benefits, Costs, Compatibility and Social Influence.

---

[51] They include diffusions theories such as Diffusion of Innovation Theory and Technology Lifecycle Theory by Everett M. Rogers, both of which are widely used in business, as well as acceptance and adoption theories such as the Theory of Planned Behavior, the Theory of Reasoned Action, the Technology Acceptance Models, and the Unified Theory of Acceptance and Use of Technology, which are more popular in the academic setting.

[52] Venkatesh, Viswanath, Michael G. Morris, Gordon B. Davis, and Fred D. Davis. "User Acceptance of Information Technology: Toward a Unified View." MIS Quarterly 27.3 (2003): 425-78. Print.

4.4.1.Benefits

In the Unified Theory of Acceptance and Use of Technology (UTAUT), this is being outlined as Performance Expectancy which is described as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance"[53], and as outlined by Venkatesh et al., they are categorized as Perceived Usefulness (TAM/TAM2, C-TAM-TPB), Extrinsic Motivation (MM), Job-fit (MPCU), Relative Advantage (IDT), and Outcome expectation (SCT) by other acceptance and diffusion models.

This is by far the most critical construct designers need to understand in order to be confident in making important design decisions. The main purpose of design to product companies is to yield innovation, and the purpose of innovation is to drive profit. The ability to identify innovation opportunities that hold promising economic potentials is absolutely essential in making the right design decisions at various stages in the process of product design and development. Adding more blades on a new razor makes no sense to consumers unless they can envision themselves benefit from the new design. People are willing to pay more for better products and services because they believe those products and services can further enhance their capabilities in achieving certain values that are important to them. Adding features or making changes that don't mesh well with potential users' behavioral patterns and value systems does help companies differentiate their product offerings, however, they will not positively affect consumer buying decisions in any significant ways.

Of course everybody knows the importance of building products that can benefit people, but only a few who understand the comparative nature of this construct. The inclusion of unique features is always welcome from a marketing point of view, but if they are not comparatively better than what can be found in competing products, they will not contribute significantly to the attractiveness of the new design. Conversely, if a competitor has an important feature that performs way better than what is offered by your current product, you will loose competitiveness. Benefits are the relative advantage in a product or service,

[53] Venkatesh. User Acceptance of Information Technology: Toward a Unified View

perceived by potential adopters, over other competing products or over not using the product at all.

The tricky part for designing relatively beneficial products or services is defining the competition. When incrementally improving an existing product, the competitors are usually other similar products on the market; but when designing for radical innovations the competition can usually be mistakenly identified as a particular category of products the new invention would try to replace. In most cases, this will cause inventors to try to mimic existing products' functionalities with their newer technologies, and end up not taking full advantage of the potentials of the new technologies used.

The accent reduction application we developed is a radically new invention aimed at replacing similar, but older technologies on the market, namely tape recorders and repeaters[54]. To avoid making the common mistake and fall into the trap of making a "modern repeater," we took the trunk-branch-twig approach in our attempt to try to identify our actual competition.

[54] A repeater is a modified tape recorder with A-B repeating functionalities designed for foreign language learners to help them improve their pronunciation accuracies through listening, imitating, recording, replaying and comparison of their recordings to the original soundtrack. It is a product designed and sold in the domestic Chinese market.

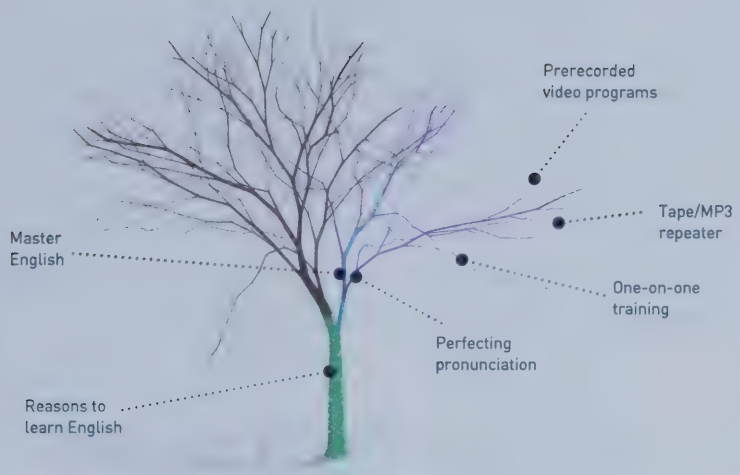


Figure 4-2 Tree of accent training

The tree trunk is of course, the various reasons for foreign language learners wanting to sound authentic when speaking the new language, and the scaffold branch includes learning different aspects of a language, building vocabulary, learning grammar, practicing pronunciations . . and the purpose of our product is situated on the lateral branch of having perfectly accurate pronunciations. On this lateral branch, their are many alternative training programs and services, as well as self-serve products and gadgets available for people to choose from. To set the bar high, we decided we should be competing with all of them, especially with the ones that offer the best performance. So we asked ourselves, what is the best product or service currently available that helps people improve their English pronunciation, and the answer we had was by hiring a professional accent training coach, and this later became our first lead-user model. Then the next question we asked was if we are creating an intelligent accent training coach, besides the actual training part, are there any other important factors that will help students in achieving their goals.

What we found, was that people learn to speak new languages mainly through im tation, but because sometimes it can be quite difficult for them to take notice

of the differences between some of the sounds they make and the sounds that native speakers make, it would take someone else, for example, a training coach, to point out their mistakes and break them down. If necessary, maybe even with examples to explain to the students where the problems were, and what the correct pronunciation should be. This process not only takes time, and a lot of practice, but also a considerable amount of reinforcements (reviews). Also, just like other learning processes, students needs to be continuously encouraged to stay confident and motivated. To create a great learning experience, all of these factors need to be put into consideration.

Usually, by this point, designers would be starting to head out for user studies and ethnographic researches, but we didn't. Once we figured out all the important requirements, we broke them further down into separate sub-requirements, and sub-questions; such as how do we keep students motivated, and what are the key elements in language pronunciation; following this we identified lead-users for each of these requirements and set out to see what researches had been done on the subject and what lessons was previously learnt through mistakes by others who tried to solve similar problems before us.

For example when asked how can we design the application so that it would motivate our students, we went to look for various studies done on motivation in teaching and learning, and found that there are intrinsic motivations such as the sense of progress, where, by giving student impressions that if they work harder they would get better results; and if they work hard enough, they will eventually reach their desired goals, would make them more motivated to study harder; and also there are extrinsic motivations where getting immediate rewards, being cheered by crowds and peers, and health competition too will get students more stimulated.

Also, to help us better understand the mental process that will take place once we show our product to our potential adopters, and anticipate the uncertainties they would face when confronted with such a radical new product, we made a list of questions and doubts that English learners might have: Does the application do demonstrations for me? Does it let me try to imitate? Does it identify

deviations in my pronunciation, intonation, stress patterns, and rhythm? Does it breakdown my mistakes? Does it show examples when I have trouble recognizing my mistakes? Does it motivate me? Does it help me make effective study plans? Does it help me practice and review? These questions later played a very important part in helping us make detailed design decisions and defining our feature sets.

In the end, by comparing the actual affordances and capabilities of the technologies available (our algorithm as well as the iOS application APIs made available by Apple Inc.) and the lists of requirements, questions that would be lingering in potential adopters' minds, and the solutions we found by going after lead-users, we came up with a list of key features we should have in our first version of the application, and they are:

1. Allowing students to listen to native speakers, and try to imitate what they hear.

2. Being able to identify students' mistakes, and demonstrate the correct pronunciations, breakdown the mistakes if necessary and give examples. (Figure 4-3)

3. Being able to let students practice and review.

4. Giving students the ability to visually see their progress as they practice and help them plan their study. (Figure 4-4)

5. Having the ability to reward students through "achievements," and letting them compete against one another.[55] (Figure 4-5)

6. Allowing others to cheer for their accomplishments, through Facebook "Likes."

[55] In Game Center, which is a feature in iOS.

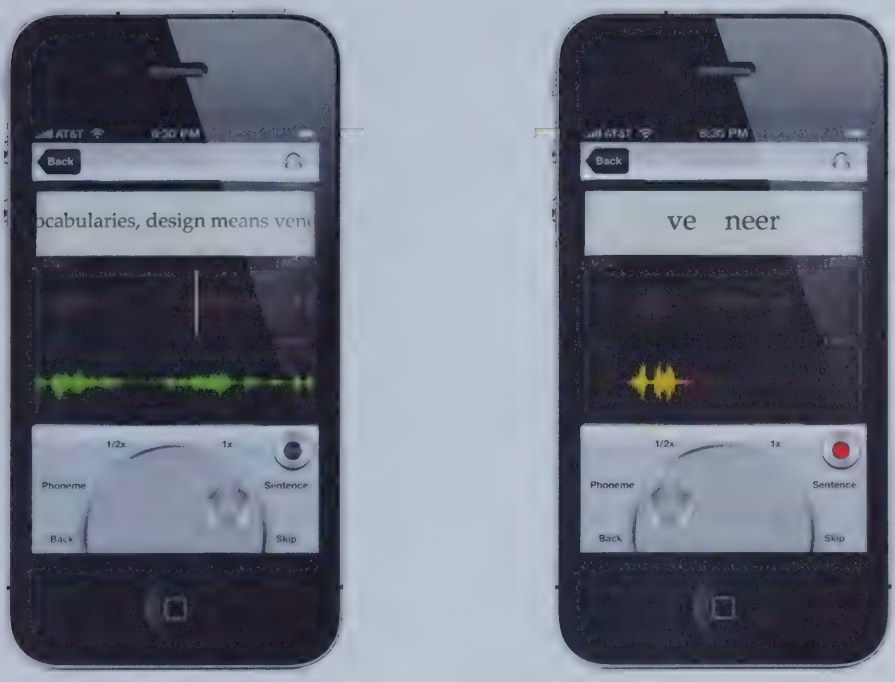


Figure 4-3 Different modes for accent training

Figure 4-4 Training progress

Figure 4-5 Gold reward

4.4.2.Costs

In UTAUT, this is being outlined as Effort Expectancy which is described as "the degree of ease associated with the use of the system."[56] According to Venkatesh, in other acceptance and diffusion models they are defined as Perceived Ease of Use (TAM/TAM2), Complexity (MPCU), and Ease of Use (IDT). In my adaptation, I also included the actual costs of buying a product or paying for a service, as it will motivate designers and engineers to seek solutions better optimized for production and operations. Yet, for the most part, the costs emphasized in this

[56] Venkatesh. User Acceptance of Information Technology: Toward a Unified View

thesis should be the interaction and transaction costs[57] involved in the process of researching about, learning and using of a product and service.

Adding more ways to benefit potential customers is not the only way to improve a company's bottom-line through innovation. Breakthrough innovations only take place periodically, and in the meantime, the performance of existing products can only improve incrementally, which usually do not produce any significant benefits to potential customers. At the same time, since many product companies do not invent original products; and instead they mostly capitalize on ideas that have good market potentials, which often results in many different companies producing very similar products with almost identical feature sets. In these cases, another very effective way to attract potential customers is to streamline the user experience of the existing product, to reduce and eliminate any unnecessary transaction costs and interaction costs.

When a product or a service is involved as a tool for helping people achieve certain goals or values, the overriding objective often lies in the results, and the process of using the product or service is usually only a chore that users has to endure through. By reducing the transaction and the interaction costs, the experience of using the tool can become less stressful, and even more enjoyable. Of course the ultimate goal is to dramatically increase the performance of the tools involved so that the users can achieve the end results faster and easier, but when the technology does not allow, reducing the actual, or perceived efforts involved in using an existing tool can at times make a big difference in affecting consumers purchasing decisions.

In other instances, transaction costs and interaction costs can be converted into benefits through design. For example, purposefully making a professional

---

[57] Transaction cost may include the time and efforts required for consumers to research and find necessary information on certain products to help them make/abandon a purchase decision, such as comparing product features between similar products, finding the lowest price, and retail locations. Transaction cost can also include the time and resources involved in traveling to the store, waiting in line, taking the product home, and setting up the product for use.

Interaction cost may include the time and efforts involved in using the product or service to achieve certain end results. For example, digging through multiple levels of an operating menu to find a desired function.

product complex and hard to use can sometimes provide consumers more benefits than costs, as people doing professional works often take pride in the skills they have mastered. If certain interaction costs cannot be avoided in designing a product or service, we can always try to convert those dully tasks into interactions that can "give something valuable back" to the users, such as pride or delightfulness.

In an attempt to minimize the cost of the application, our team mainly focused on user-centered design and usability engineering. Same as what we did for the first part, we came up with a list of doubts potential adopters might have, including: Does the application motivates me? (Again) Does it 'sense' my need for guidance when I need it. Does it help me concentrate on my lessons? Do I need to spend time learning how to use it? Do I need to spend a lot of efforts looking for course contents that's right for me? How much will it cost me?

To streamline the interaction and user experience, we needed to base our design on a mental model users are already familiar with, "Understand the activity, and the device is understandable."[58] So we took the mental model[59] of the interaction between a training coach and a student (Figure 4-6), and applied on top of our design. Also we adopted a skeuomorphic style[60] in designing the graphical user interface for this application to bring more friendliness and familiarity for our users.

---

[58] Norman. Human-centered Design Considered Harmful.

[59] Young. Mental Models: Aligning Design Strategy with Human Behavior.

In Young's book, she defined Mental Models as affinity diagrams of behaviors made from ethnographic data gathered from audience representatives which give deep understanding of people's motivations and thought-processes, along with the emotional and philosophical landscape in which they are operating.

[60] An object or feature which imitates the design of a similar artifact in another material.

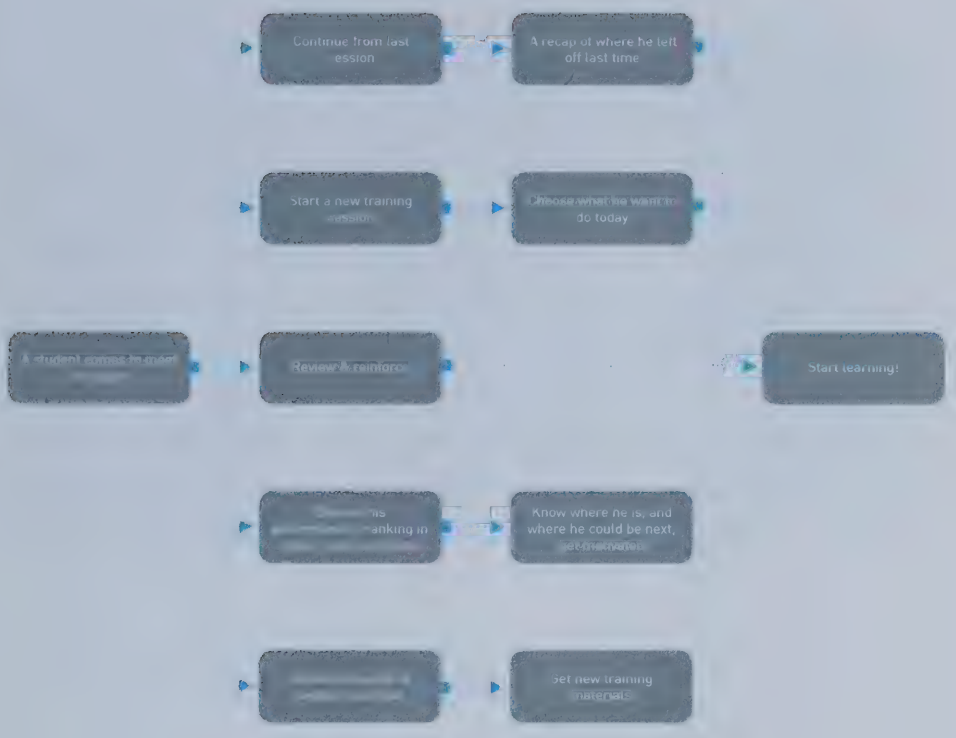


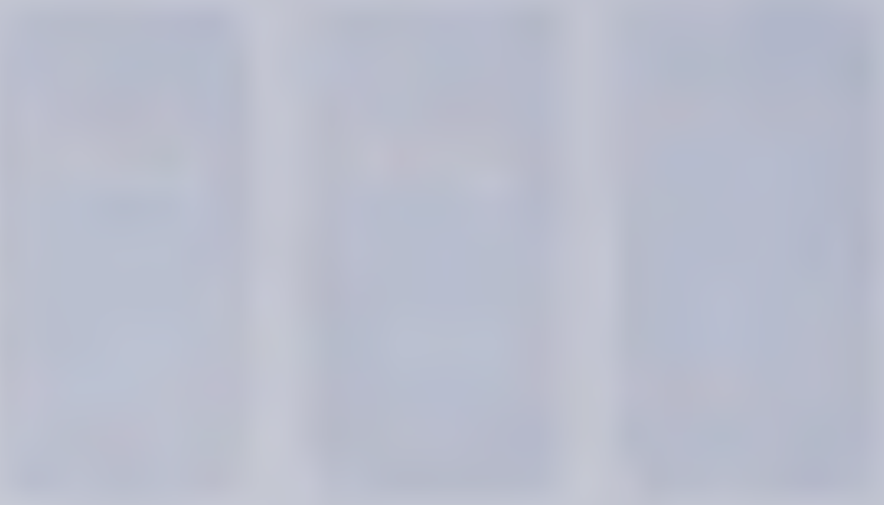
Figure 4-6 Mental model between coach and student

To training coaches, everything begins with an assessment, in order to help students improve, they need to get to know them first. To students, imitation and positive reinforcements are keys to improvements. We designed the application so that when students launch the application for the first time, they are presented with a single book on a table as the only menu option (and the contents on the table will grow as the student progresses through the training) (Figure 4-7). Opening the book will reveal a list of articles for the students to choose from. When selected, the full article will be shown in an interface that's striped down to the bare essentials. Students could preview the contents before the assessments begin and familiarize themselves with the test contents. When they want to focus on the contents, everything else (controls, and buttons) will fade away to minimize distraction. Once the assessment starts, students can elect to have the coach (the application) demonstrate each sentence and try to read after the coach. They can also choose to hear their own voice through their

headphones as they speak into the mic. Once they finish their sentence, the contents will automatically advance to the next sentence. When the coach is demonstrating, a shadow will be casted on the paper, indicating someone else is reading the sentence, and when it is the student's turn, a microphone will take its place instead (Figure 4-8). In case the students run into words they are not familiar with, they can easily look up their meanings and find out how to pronounce those words with ease.[61] Should they feel they need a break or want to call for assistance, it would be just a single tap away. In rare cases where the coach fails to recognize some of the words read by the student, it will try to quietly notify the student without being interruptive (Figure 4-9). They can ignore the warning and stay on their course or they can respond to the coach by going back and reread the sentence.

[61] A built-in feature in iOS 5

Figure 4-7 Adaptive intelligent menu



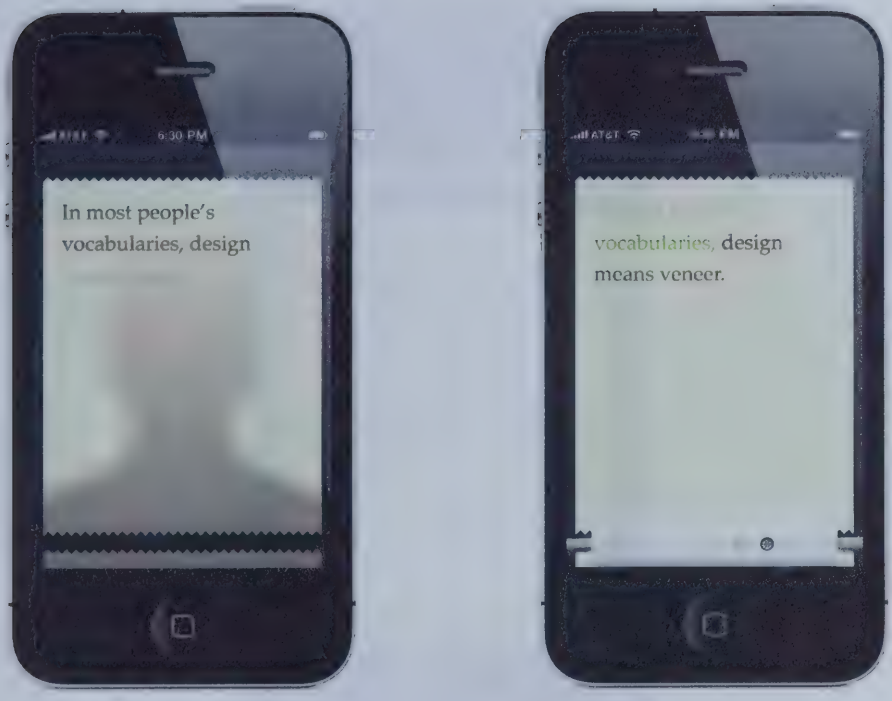


Figure 4-8 Assessment

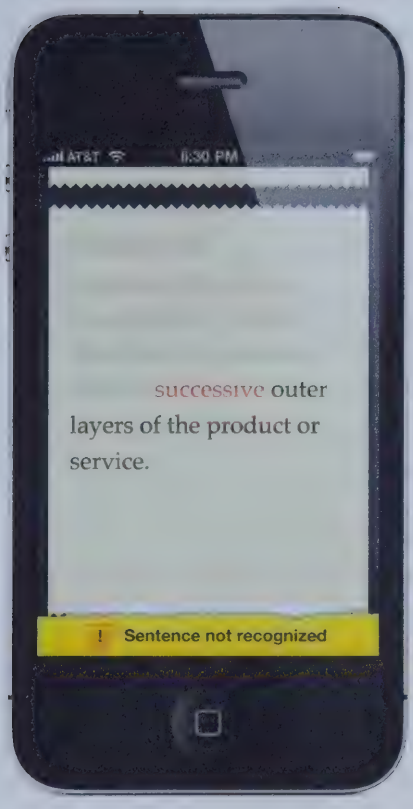


Figure 4-9 Notification

If a student has to run before completing a session, that's fine too, we designed it so that all progress will be saved, and the next time the student gets to the main menu, a bookmark will appear, sticking out slightly from the top edge of the textbook, indicating the progress. A simple tap on the bookmark will take the student right back to where he left off, no more complex menus, no more trying to remember where to begin.

Once the assessment is completed a detailed report of the student's performance will be generated, The "coach" will tell the student how well he or she did, and make a study list so the student can always first work on the things that will give him or her the biggest improvements. The students can track their progress, get achievements, compete with their friends and the rest of the world

through Game Center, and even share their trophies on Facebook and collect 'likes'. All these will keep them highly motivated. When going back to the articles the students have already read, they would only see their most prioritized targets so they are never overwhelmed. Master all 'Red' words, which are the ones with the greatest deviations, they will get to see the 'Orange' ones next.

Tapping on any of the highlighted words, the coach will show the students exactly where they did wrong, and students are always encouraged to give it another try even if it's only for practice. To make the experience feel more familiar, the interface mimics students' old cassettes, all sounds are "recorded on rolls of tapes." Tapping on the tapes will playback the corresponding recordings. To help students reinforce, the coach would try to arrange all similar and repeating mistakes, and line them all up in a roll, so students can see the pattern themselves and fortify what they have learnt thus far. If a student ever gets confused, and couldn't get a word right after multiple attempts, the coach will come in and try to break it down further for the student to see. When he/she feels a bit more comfortable, he/she would get to try the word in whole again.

When a student has made enough progress, it would be nice if he/she can go back and do a little review, a stack of study cards will show up to the right of the textbook, providing a fast-paced word only mode for the student to quick review and reinforce the words he has learnt thus far.

By separating Costs into its own category, made it extremely clear to our design and development team, that reducing friction in a design should not be treated as a standalone task, and instead, it should be carried out in concert with other design considerations with the aim of stripping away unnecessary road blocks along the pathway we provide for our users to achieve their goals through using our product. The goal of designing for trimming costs is not only to make the product simple, easy to use, but more importantly, to make the design more focused on its key purposes, and at the same time, accentuating and communicating those values to the potential adopters.

4.4.3.Compatibility

Compatibility could have been merged into costs, because by increasing a design's compatibility with potential adopters existing values, needs and experiences, the interaction and transaction costs can be substantially reduced. However, unlike other road blocks, which can vary greatly from case to case, compatibility is a common cost that all design projects should strive to address.

Similar terms were used to describe this construct in UTAUT as well as various other adoption and diffusion models [62], including Facilitating Conditions (UTAUT, MPCU), Perceived Behavior Control (TPB/DTPB, C-TAM-TPB), and compatibility (IDT).

Ensuring high compatibility in the design of products can benefit a product company in two ways. For one, it will help potential adopters lower their uncertainties down to a manageable level which will further reduce frictions in product companies facilitating these potential adopters to make favorable adoption decisions. This is especially important in the introduction of radical new products. For another, designing products that are highly compatible with other products offered by the same company can create a platform lock-in effect, that will contribute to customer loyalty in the long run. On the contrary, companies that develop radical new products without keeping compatibility in mind run the risk of upsetting their existing customers and losing long time customers.

For our particular project, the only consideration we emphasized was how can we make sure the contents of our training application fits into our potential adopters' existing learning experience. We believe by having contents matching with what our potential adopters are already learning in other English language training courses would be absolutely crucial in helping our product achieving the initial market penetration we needed.

---

[62] Venkatesh. User Acceptance of Information Technology: Toward a Unified View

4.4.4.Social Influence

Last is Social Influence, which are also being called [63] Social Influence (UTAUT), Subjective Norm (TRA, TAM2, TPB/DTPB, C-TAM-TPB), Social Factors (MPCU), and Image (IDT). Some may argue this last construct is not as important as the previous three, as it neither contributes to the perceived valuableness of designs, nor does it reduce the uncertainties and perceived difficulties associated with adopting new products or services. However, if we consider the domino effect in innovation and technology diffusion, having a design that helps spread itself can at times, be quite important.

Social Influence, as Venkatesh explains[64], is "the degree to which an individual perceives that important others believe he or she should use the new system." and in Innovation Diffusion Theory (IDT), it is defined as Image, which means "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system." The implication of Social Influence has over design is that if a design enhances earlier adopters social status, they would be more likely to recommend it to other potential adopters, which will no doubt increase the rate of adoption and diffusion.

In our iPhone application design, we incorporated a great number of "fancy" animated transitions between actions, not only for providing visual cues the help people better understand the underlying organizational structures of the application, but also to make our users "look cool" and prompt them to show off among their family and friends. The Facebook sharing feature we designed, as well as the incorporation of Game Center support are also simple tactics which we thought would be helpful for the spreading of our product.

[63] Venkatesh. User Acceptance of Information Technology: Toward a Unified View

[64] Venkatesh. User Acceptance of Information Technology: Toward a Unified View

4.5.Reflection

The accent reduction iPhone application project was carried out in the hope of testing the practicality of the four major design guidelines proposed by this thesis, which was aimed at increasing companies' innovative capacities. Through the process of conceptualizing, designing, and implementing this application, most of the four principles has been proven to be beneficial for the product company.

Letting purposes and values drive our decision making process, has led the team to many unexpected discoveries which resulted in a line of innovative features, such as the inclusion of functions specifically tailored for motivating students. It also provided the team a sense-making platform for help aligning the goals and visions of each individual specialist, from designers to managers to front and backend developers, and making sure everybody involved is working towards the same goals. It has allowed the designer and the developers to work together on the design and implementation of the product from start to end, and seek solutions concurrently from both the human end and the technology end to arrive at an optimum solution between the two. On the one hand, because our process was based on purposes and values, the exploration process was not tightly limited by available technologies, but on the other hand, because the developers were actively engaged in the solution finding process, we were able to make otherwise difficult connections between our ideas and requirements and the technologies we can use, for instance, the use of Game Center in an educational application.

By keeping a firm grip on the core functionalities, and at the same time, letting technologies freely evolve on their own, allowed us a very flexible development plan that can be stretched far into the future. As new technologies become available, we would be able to seize control and exploit their potentials to our advantage rapidly. For example, we recognized that learning new words is a common lateral value for accent reduction training students. However, we don't currently have the capacity to develop our own built-in dictionary, so initially, we listed dictionary functionality as a future development priority, and decided to

leave it out of our initial release. However, when Apple announced the inclusion of a system wide dictionary and speech API in iOS 5, we quickly took advantage of it and included the functionality in the design of our application. Anticipating new capabilities, not new technologies has given us a first mover advantage in developing a cutting edge product.

Unfortunately, in this project, we were not able to assess the effectiveness of the last two principles since this project only marks an early beta version of our product, and that there has been several significant development delays. However, by laying down the groundwork and documenting a wide variety of purposes, values, and capability requirements, we have already collected a considerable amount of objectives for our future product development plans, some of which are already making their way into our second version and possibly even the third version of this application, such as accent recognition and classification and they were all based on our original vision, not the first version of our shipping product.

Due to delays in development, we were not able to ship the product in time to assess its adoption performances, and this remains a major disappointment for this thesis. However, since the development is wrapping up quickly, assessment of the effects and contributions of my last principle is highly recommended for a future study.

In the mean time, I was able to get some very positive feedbacks from the developers working on the project; and they mostly pivot around three key points. The first, is that by taking this alternative approach, the developers felt the goals of the project were very well defined right from the beginning of the project and were able to stay almost unchanged throughout the design and implementation process with almost no debate or dispute between various stakeholders; and at the same time, the direction for the product's future development is also very well laid out. The second, is that the developers felt that they were given a lot more freedom in trying out different technologies and were more involved in making actual design decisions as opposed to their previous linear design and development process where they merely worked to implement whatever features

designers have specified for them. The third, is that through using human values as design guidelines, the developers were able to confidently make many important decisions on their own while dealing with unexpected or unspecified problems without needing to refer back to the designer right away, which cut the lead time considerably.

5. CONCLUSION

This thesis revealed a series of fundamental misalignments between the goals, purposes and motivations of businesses, consumers, inventors, designers and technologists, and the confusion it has caused among each different group. Based on the analysis presented in this thesis, I now can conclude that businesses are driven by economic incentives, and the way they can realize their values is by providing products and services that are valuable to people, or else, they won't have any customers. Therefore, the design and development of new products and services should be mostly focused on understanding how people perceive and associate values to things, and providing products and services that attends to people's value systems. In the process of doing that, design practitioners need to take into account the varying motivators existing between the various parties involved and coordinate in the decision making process that's governing the design and implementation of marketable new products and services.

It is worth noting that the problems identified in this thesis are not entirely new, but instead are closely related to what is widely acknowledged in the design research community as problem-solving theories. As Kees Dorst pointed out,[65] the three major problems with the use of the term "design problems" in design methodology are:

> *1. The "design problem" is not knowable at any specific point in the design process.*
>
> *2. The "design problem" is hard to identify because it evolves in the design process.*
>
> *3. The connotations of the very concepts that are used to describe a "design problem" are shifting as a part of the design effort.*

By recognizing these widely acknowledged problems, and taking a slightly different view at the design and problem solving process. This thesis was able to

[65] Dorst, Kees. "Design Problems and Design Paradoxes." Design Issues 22.3 (2006): 4-17. Print.

propose an alternative method for identifying and defining design problems and seeking solutions. The theories outlined in this thesis can be particularly useful in solving design paradoxes where conflicting design requirements clash.

Understanding that the implementation of design ideas and concepts is crucial to making great products, and acknowledging the fact that designers are usually not the best candidates for solving implementation challenges is pointing us toward a much more concurrent process in which designers and developers and/or engineers are required to work collaboratively to solve many of todays complex design problems. Since the implementation of products and services are mostly combinations of technologies, developers' and engineers' usual mindsets are for the most part technology inspired, not human centered. Although this difference in worldview is causing a great divide between designers and engineers, making it almost impossible for the two groups to work together towards the same goals, I believe by deconstructing design questions into sub-questions that pose specific sub-requirements will in fact motivate engineers and developers to work more creatively and relocate the focus of their technical expertise into solving human centered problems.

As for businesses, all causes aside, their ultimate goal is market share and sales figures. Building great products simply cannot satisfy their needs, instead the holy grail lies in the ability to design and build products that sells. For decades, there have been active studies in the adoption and diffusion of innovations and technologies among both business practitioners as well as academic scholars aimed at understanding peoples decision making processes in adopting or rejecting new innovations and technologies. However there seems to be virtually no crossing between these studies and design research. Since one of the most prominent use of product design today, is to help companies achieve market success, the incorporation and exploitation of such knowledge in the actual product creation process is urgently needed.

Although this thesis gave a brief overview of the various hidden challenges design practitioners are facing today, I have not been able to fully explain and address many of the challenges in great detail. The framework I am trying to

build is still in very preliminary shapes, and a great deal of future investigations is highly expected.

6. BIBLIOGRAPHY

1. Anderson, Greg. Living Life on Purpose: a Guide to Creating a Life of Success and Significance. [San Francisco]: HarperSanFrancisco, 1997. Print.

2. Arthur, W. Brian. *The Nature of Technology: What It Is and How It Evolves*. New York: Free, 2009. Print.

3. Buxton Collection. Microsoft. Web. <http://research.microsoft.com/en-us/um/people/bibuxton/buxtoncollection/browse.aspx>.

4. Chandy, Rajesh K., and Gerard J. Tellis. "Organizing for Radical Product Innovation: The Overlooked Role of Willingness to Cannibalize." *Journal of Marketing Research* 35.4 (1998): 474-87. JSTOR. Web. 13 Nov. 2011. <http://www.jstor.org/stable/3152166>.

5. Christensen, Clayton M. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Boston, MA: Harvard Business School, 1997. Print.

6. Cooper, Alan, Robert Reimann, and Dave Cronin. "Goal-Directed Design." *About Face 3: the Essentials of Interaction Design*. Indianapolis, IN: Wiley Pub., 2007. Print.

7. Dorst, Kees. "Design Problems and Design Paradoxes." *Design Issues* 22.3 (2006): 4-17. Print.

8. Eliot, T. S. "Philip Massinger." *The Sacred Wood: Essays on Poetry and Criticism*. London: Methuen &, 1950. Print.

9. Henderson, R. M., and K. B. Clark. "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms." *Administrative Science Quarterly* 35.1 (1990): 9-30. Print.

10. Hillmer, Ute. "Existing Theories considering Technology Adoption." *Technology Acceptance in Mechatronics the Influence of Identity on Technology Acceptance*. Wiesbaden: Gabler, 2009. 9-28. Print.

11. Isaacson, Walter. *Steve Jobs*. New York: Simon & Schuster, 2011. Print.

12. Johnson, Steven. *Where Good Ideas Come From: the Natural History of Innovation*. New York: Riverhead, 2010. Print.

13. Memory & Imagination: *New Pathways to the Library of Congress*. Dir. Michael R. Lawrence. Michael Lawrence Films. DVD.

14. Moggridge, Bill. "Adopting Technology." *Designing Interactions*. Cambridge, MA: MIT, 2007. 293. Print.

15. Moggridge, Bill. *Designing Media*. Cambridge, MA: MIT, 2010. Print.

16. Moore, Geoffrey A. *Crossing the Chasm: Marketing and Selling Disruptive Products to Mainstream Customers*. New York: CollinsBusiness Essentials, 2006. Print.

17. Norman, Donald A. "Human-centered Design Considered Harmful." *Interactions* 12.4 (2005): 14-19. Print.

18. Norman, Donald A. "Technology First, Needs Last: the Research-product Gulf." *Interactions* 17 (2010): 38-42. Print.

19. Norman, Donald A. *The Design of Everyday Things*. London: MIT, 1998. Print.

20. Norman, Donald A. "The Research-Practice Gulf." IIT Design Research Conference 2010. Spertus Institute, Chicago. May 2010. Speech.

21. Rogers, Everett M. *Diffusion of Innovations*. 5th ed. New York: Free, 2003. Print.

22. Rowe, Lloyd A., and William B. Boise. "Organizational Innovation: Current Research and Evolving Concepts." *Public Administration Review* 34.3 (1974): 284-93. Print.

23. Schauer, Brandon. "The Business Case for (or Against) UX." Speech. User Interface 16 Conference. Boston. *LukeW Ideation* + Design. Luke Wroblewski, 9 Nov. 2011. Web. 10 Nov. 2011. <http://www.lukew.com/ff/entry.asp?1445>.

24. Sinek, Simon. Start with Why: How Great Leaders Inspire Everyone to Take Action. New York: Portfolio, 2009. Print.

25. *The Umbrella Man*. Prod. Errol Morris. Perf. Josiah Thompson. The New York Times, 22 Nov. 2011. Web. <http://video.nytimes.com/video/2011/11/21/opinion/100000001183275/the-umbrella-man.html>.

26. Urabe, Kuniyoshi, John Child, and Tadao Kagono. "Innovation and the Japanese Management System." *Innovation and Management: International Comparisons.* Berlin: W. De Gruyter, 1988. 3. Print.

27. Venkatesh, Viswanath, Michael G. Morris, Gordon B. Davis, and Fred D. Davis. "User Acceptance of Information Technology: Toward a Unified View." *MIS Quarterly* 27.3 (2003): 425-78. Print.

28. Verganti, Roberto. *Design-driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean.* Boston, MA: Harvard Business, 2009. Print.

29. von Hippel, Eric. *Democratizing Innovation.* Cambridge, MA: MIT, 2005. Print.

30. von Hippel, Eric. *The Sources of Innovation.* New York: Oxford UP, 1988. Print.

31. Young, Indi. *Mental Models: Aligning Design Strategy with Human Behavior.* Brooklyn, NY: Rosenfeld Media, 2008. Print.

Huiwen Ji

Huiwen.ji@me.com

Interaction designer, industrial designer, design instructor,
and innovation adoption and diffusion specialist.

Education

Master of Design
2009 - 2012

University of Alberta, Department of Art and Design, Edmonton, Alberta, Canada

Thesis: Innovation, Technology, Design: Refocusing Product Creation on Empowerment

Area of Study: Interaction design; innovation adoption and diffusion

Bachelor of Engineering in Industrial Design
2004 - 2008

University of Science and Technology Beijing, Beijing, China

Thesis: Tangible User Interface in Product Interaction Design

Area of Study: Interaction design; Tangible User Interface design; product design

Experience

Instructor "Product Design Principles and Practices"
2011 - 2012

University of Alberta, Department of Art and Design, Edmonton, Alberta, Canada

A studio-based course which implements design principles and practices with a focus on their application to product design for batch production and mass production.

Instructor "Design Fundamentals"
2011

University of Alberta, Department of Art and Design, Edmonton, Alberta, Canada

Studio-based introduction to the conceptual and practical concerns of the design disciplines. Two- and three-dimensional design-related studies.

Teaching Assistant
2010

University of Alberta, Department of Art and Design, Edmonton, Alberta, Canada

Course title is Design Fundamentals.

Research Assistant - Visual Resource Centre
2009 - 2010

University of Alberta, Department of Art and Design, Edmonton, Alberta, Canada

Interaction Designer
2009 - 2010

Inde-x, Shenzhen, China

Software interaction and user interface design; web design

Interaction Designer Intern
2007 - 2008

Microsoft Research, Interaction Design Group, Beijing, China

Hardware and software interaction design; help shipped uPad in small quantity to Microsoft Research employees

Huiwen Ji

Interaction designer, industrial designer, design instructor,
and innovation adoption and diffusion specialist.

Huiwen.ji@me.com

Freelancer

2006 - Present

Software interaction and user interface design; web design; visual identity design; industrial design

---

Awards

University of Alberta Master of Design Scholarship	2009, 2010
Microsoft Research "Star of Tomorrow" Award	2008
Interior Motives Design Award Finalist	2006
Gold Key Award for Excellence in Visual Arts, North Carolina Scholastic Art Awards	2008


Ji, Hui-yan
Master of Design